THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 49 JUNE, 1943 No. 6

ROENTGENOLOGIC CHANGES IN THE SMALL INTESTINE IN THE PRESENCE OF THE HOOKWORM*

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INTRODUCTION

ROENTGENOLOGISTS, as a group, paid little attention to the small intestine until the last decade. Diagnosis of disease in this portion of the gastrointestinal tract was almost entirely confined to an occasional case of neoplasm or the presence of ileus. In the past ten years, however, Mackie and his associates,[4,5] Snell and Camp,[8,9] Golden,[1,2] Pendergrass and his coworkers[6,7] and Kantor[3] have contributed much to our knowledge of the abnormal physiology of the small intestine. The list of diseases or clinical entities now known to cause the alterations in the appearance and the function of the small intestine known as the "deficiency pattern", is quite extensive. They are best listed in outline form.

I. Nutritional disturbances
  A. Primary (no obvious anatomic cause)
    1. Celiac disease
    2. Tropical sprue
    3. Non-tropical sprue (idiopathic steatorrhea)
    4. Deficient diet (as pellagra)
  B. Secondary to disease of the gastrointestinal tract
    1. Peptic ulcer
    2. Cancer
    3. Tuberculosis of the small intestine
    4. Biliary or pancreatic disease
    5. Chronic ulcerative colitis
    6. Regional ileitis
    7. Sclerosing inflammation of the mesenteric lymphatics

II. Other causes
  1. Hypoproteinemia (as nephrosis)
  2. Diabetes insipidus
  3. Parathyroid disease
  4. Allergic states

It is not within the scope of this paper to discuss these diseases. It is our purpose at this time to add infestation with the hookworm, *Necator americanus*, to the list of those diseases capable of causing the deficiency pattern.

HOOKWORM INFESTATION

The hookworm is widely distributed throughout the tropical and subtropical re-

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FIG. 1. (J. B.) A normal small intestine one and one-half hours after administration of barium. Note the even caliber of the lumen of the intestine, the continuous column of barium and the delicate, sharply defined mucosal folds. Contrast this appearance with that of the succeeding roentgenograms.

gions of the world, but *Necator americanus* is the only hookworm of importance to man in the Western Hemisphere. This parasite is found in the southern half of the United States, the Caribbean Islands, Central America and the northern portion of South America. It must be remembered that persons who have lived and travelled in these portions of the world may acquire and harbor these parasites when they return to more temperate climates.

Necator americanus, in its adult phase, inhabits the small intestine, especially the middle third, and is responsible for the syndrome of hookworm disease. The males measure 7–9 mm. in length by 0.3 mm. in diameter; the females are slightly larger. The details of the life cycle and the morphology have been clearly worked out and are described in the literature on parasitology.

Hookworm infestation usually begins in childhood when exposure is frequent, since in the regions mentioned children usually go barefoot, both by preference and for reasons of economy. The worms are known to persist in the small intestine for at least six to seven years following the last infestation, but probably remain for longer periods.

The typical patient suffering from hookworm disease is chronically tired, feels "below par" and complains of lassitude. Heartburn, flatulence, epigastric fullness and pain are relatively frequent. The patient is usually thin and has a sallow complexion. Laboratory studies often reveal a secondary hypochromic anemia (due to chronic blood loss) and an eosinophilia.

In severe cases these symptoms are more pronounced. The lassitude becomes apathy, the gastrointestinal symptoms become more severe and the anemia quite pronounced.

TECHNIQUE OF EXAMINATION

Four ounces of barium sulfate suspended in 5 ounces of normal saline were administered in the morning to the fasting patient. The usual roentgenoscopic examination of the stomach and duodenal bulb was made. The patient was examined at intervals of one-half hour either roentgenoscopically or roentgenographically, until the head of the barium column reached the cecum and the remainder of the barium was in the ileum. At this time, usually three to four hours after the start of the examination, the patient was given a glass of milk and a slice of bread and butter (to test the food reflex). A roentgenogram was then made in one-half hour and thereafter as indicated until the barium cleared the small intestine. The examination was discontinued at nine hours even if an ileal residue was present.

SELECTION OF CASES

Complete small intestinal studies were made on 97 young white soldiers (eighteen to thirty-four years of age) in whose stools the ova of *Necator americanus* were present.

In almost all instances the ova were detected in two or more stool specimens. None of these men had any systemic disease known to cause alterations in the small intestinal pattern; none had a remote or recent history of inadequate diet or chronic alcoholism; none had demonstrable organic disease of the gastrointestinal tract. Two men were Puerto Ricans, all the rest had been born and reared in southern states with two exceptions.

On the basis of the clinical findings alone, these cases were divided into two groups, clinically significant "hookworm disease," and incidental, asymptomatic "hookworm infestation."

A man who passed the ova of *Necator americanus* in his stool was classed as suffering from clinically significant "hookworm disease" only if he entered the hospital with the typical clinical syndrome, with anemia or with chronic complaints referable to the gastrointestinal tract, and provided that he suffered from no other demonstrable disease, systemic or gastrointestinal. There were 44 such cases.

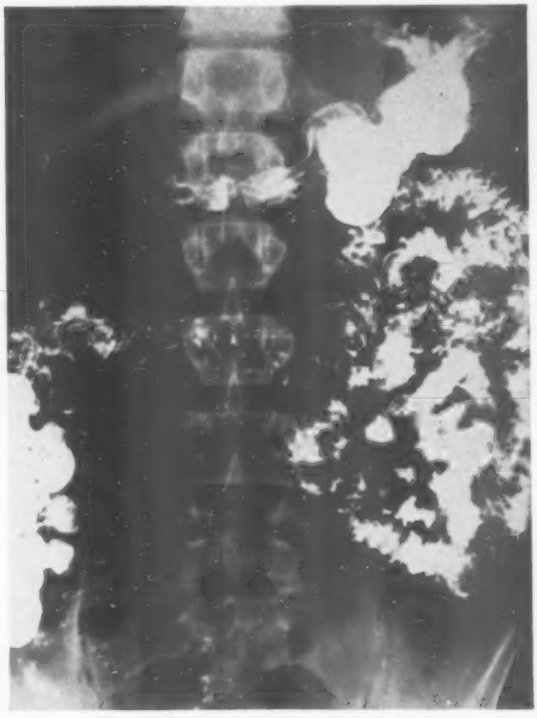

Fig. 2. (L. W.) Dietary deficiency due to limited diet before and after operation for perforated gastric ulcer. This roentgenogram made immediately after roentgenoscopy of the stomach and duodenum shows a moderately severe distortion of the jejunal pattern. There is coarsening of the mucosal folds and some segmentation. Barium administered six hours earlier is in the cecum and ascending colon. The jejunal changes were found incidentally on a gastrointestinal series (see Fig. 3).

Fig. 3. (L. W.) Same case as Figure 2. After administration of liver extract twice weekly for five weeks this roentgenogram, made at one-half hour, shows the mucosal pattern to be almost normal, and the segmentation to be absent. This case is presented to illustrate the type of findings described in the literature as the "deficiency pattern." Note the similarity of these changes to those seen in the succeeding reproductions, which, however, are due to the hookworm.

Any patient in whose stool ova were found on a routine examination, who had no gastrointestinal symptoms, no anemia, no loss of "pep" and no lassitude was regarded as a case of incidental, asymptomatic "hookworm infestation," of no clinical significance. There were 53 such cases.

It should be especially noted that this classification was made entirely on clinical

FIG. 4. (L. P.) "Hookworm disease." At one and one-half hours a single loop of jejunum exhibits coarsening of the mucosal folds with one area of segmentation (arrows). The jejunum is otherwise normal. The barium column has reached the hepatic flexure, indicating hypermotility. Minimal changes. (See Fig. 5.)

grounds, and that the roentgenograms were examined objectively for the presence of variations from the normal pattern.

ROENTGEN MANIFESTATIONS

The abnormalities of the physiology of the small intestine known as the "deficiency pattern" are manifested by variations from the normal in the appearance and function of the mucous membrane (including the muscularis mucosa) and the tunica muscularis propria (or true muscle coat).

These may be outlined as follows:

I. Abnormal function of the mucous membrane
  A. Pattern changes of the mucosa (in increasing severity)
    1. Coarsening of folds
    2. Irregularities of folds
    3. Flocculation
    4. Obliteration of folds
II. Abnormal function of tunica muscularis
  A. Motility
    1. Hypermotility
    2. Hypomotility
  B. Tonicity
    1. Hypertonicity
      a. Segmentation
    2. Hypotonicity
      a. Dilatation

These same alterations have been encountered in this study. It is evident that a uniform type of response occurs in the small intestine as the result of a number of different influences.

Coarsening of the mucosal folds in the mid and distal jejunum was the earliest var-

FIG. 5. (L. P.) Same case as Figure 4. Ten weeks after successful anthelmintic therapy this roentgenogram was made at one hour after the administration of barium. There is still slight hypermotility, but the barium column is continuous and the mucosal folds are normal. There is practically a complete return to the normal appearance. The patient is clinically well.

iation from the normal found in the mucosa. The hookworm itself is too small to demonstrate roentgenographically. In the more advanced cases, irregularities of the mucosa were present and finally the mucosa was entirely obliterated in a few severe cases. Flocculation was seen in a number of cases, but always in moderately and severely altered small intestines.

Alterations in the muscular function were frequently noted. Hypermotility (barium reaching the cecum in one hour or less) and localized areas of segmentation were common features, but hypomotility and dilatation (loss of tone) were characteristically seen only in far advanced cases. All of these changes are clearly illustrated in one or more of the roentgenograms reproduced herewith. The legends are self explanatory.

In some cases the mucosal changes were visible first, and in others, segmentation or hypermotility (muscular functions) were the first abnormal findings. In well marked cases both mucosal and muscular changes were always present, although in any given case either might predominate.

Fig. 6. (C. T.) "Hookworm disease." Roentgenogram made at one hour reveals definite hypermotility with break up of the barium column. There is dilatation of a loop of proximal jejunum, coarsening of the mucosal folds and moderately severe segmentation. Moderately severe changes. (See Fig. 7.)

Fig. 7. (C. T.) Same case as Figure 6. Twenty weeks after successful anthelmintic therapy this roentgenogram made at one and one-half hours shows that the hypermotility and segmentation are no longer present. The mucosal pattern still shows some abnormality. The patient was clinically cured.

In almost every case an adequate food reflex was present. In the few cases in which the reflex was absent or diminished there was no relation to the presence or absence of other abnormal roentgen manifestations.

The mucosal folds in the ileum are normally quite low, and therefore alterations in the mucosal pattern were not as clear cut as in the jejunum. Furthermore, segmentation and stasis occurred in the distal half of the ileum when the rest of the small intestine was quite normal, and when the patients had no symptoms. It appears that

FIG. 8. (A. D.) "Hookworm disease." This roentgenogram at one and one-half hours presents severe distortion of the normal pattern in the jejunum. There is marked segmentation (arrows), break up of the barium column and coarsening of the mucosal pattern, which in some areas is obliterated. Severe changes. (See Fig. 9.)

changes in the ileum are not as well defined as those in the jejunum, and therefore not valuable as a diagnostic guide.

An occasional patient was encountered whose small intestine appeared to be normal at the start of the examination and then abruptly presented marked changes from the normal in succeeding roentgenograms. Conversely, an occasional small intestine was seen which appeared to be abnormal at the start, but which after one or two hours assumed a normal pattern. These findings were confirmed on re-examination. The significance of these alterations is not clear. Food allergy was excluded by the fact that these changes occurred before the test meal was given.

Each small intestine study was graded and placed into one of four groups on the basis of the presence or the severity of these abnormal findings. These groups were entitled normal small intestine, and minimal, moderate and severe alterations from the normal.

In the 44 cases of "hookworm disease" the following distribution occurred:

Normal small intestine	4
Minimal alterations	14
Moderately severe alterations	11
Severe alterations	15

In the 53 cases of "hookworm infestation" the following distribution occurred:

Normal small intestine	33
Minimal alterations	16
Moderately severe alterations	2
Severe alterations	2

These tables show that 40 of 44 cases of clinically significant "hookworm disease"

FIG. 9. (A. D.) Same case as Figure 8. Ten weeks after anthelmintic therapy this roentgenogram taken at one and one-half hours shows remarkable improvement but not complete return to normal. There is still present a large dilated loop of jejunum which has coarsened folds (arrows), but the remainder of the mucosal folds are almost normal and the barium column is more nearly continuous. The patient was clinically cured.

in this study showed pathologic changes in the small intestine. Of the cases without symptoms, i.e. the incidental cases of "hookworm infestation" only 4 of 53 cases showed more than minimal changes.

It has long been established that the severity of the infestation with the hookworm roughly parallels the severity of the symptoms. A significant correlation therefore exists between the presence and the extent of the physiologic alterations seen on the roentgenograms, the clinical findings and the severity of the hookworm disease. This close relationship further indicates that the hookworm is the sole cause of the alterations from the normal pattern encountered in this study.

It should be noted at this point that the 2 cases which were entirely asymptomatic, but which showed severely damaged small intestines, both gave a history of having been treated for hookworm in childhood, and of having had the ground itch on numerous occasions. Therefore, in these instances it is probable that the pathologic manifestations now visible were due to an infestation of considerable severity in the past which caused irreparable damage to the small intestine. This is further supported by the fact that re-examination following successful anthelmintic therapy showed no change from the appearance seen on the original examination.

The 4 patients with "hookworm disease" whose small intestines were normal by roentgen examination were borderline cases, i.e. the symptoms were mild and vague. It is probable that they should have been classed as incidental cases but at the time of the original interview they were regarded as significant, and we have not changed the grouping.

Fig. 10. (J. S.) "Hookworm disease." Roentgenogram made at three and one-half hours shows that no barium has reached the cecum. The barium is clumped in the ileum, but throughout the jejunum there is definite and well marked flocculation, indicating a disturbance of the mucosal pattern.

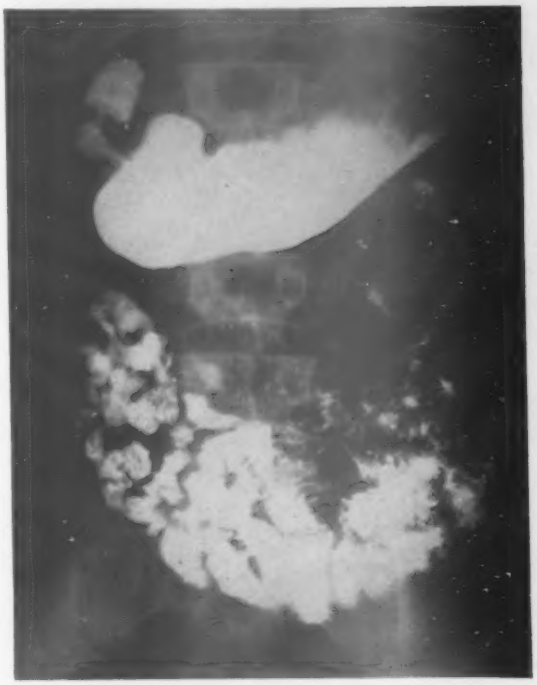

Fig. 11. (M. W.) "Hookworm disease." Roentgenogram made at one-half hour demonstrates complete obliteration of the mucosa and severe segmentation. This patient was critically ill, with a red blood cell count of 1,000,000, and required two transfusions before this study was made.

FIG. 12. (M. W.) Same case as Figure 11, same day. This roentgenogram was made at two hours. There is demonstrated a delayed gastric emptying time and hypomotility in the small intestine. The segmentation is pronounced. The jejunal mucosa has a "washed out" appearance. This is a very severe disturbance. (See Fig. 13.)

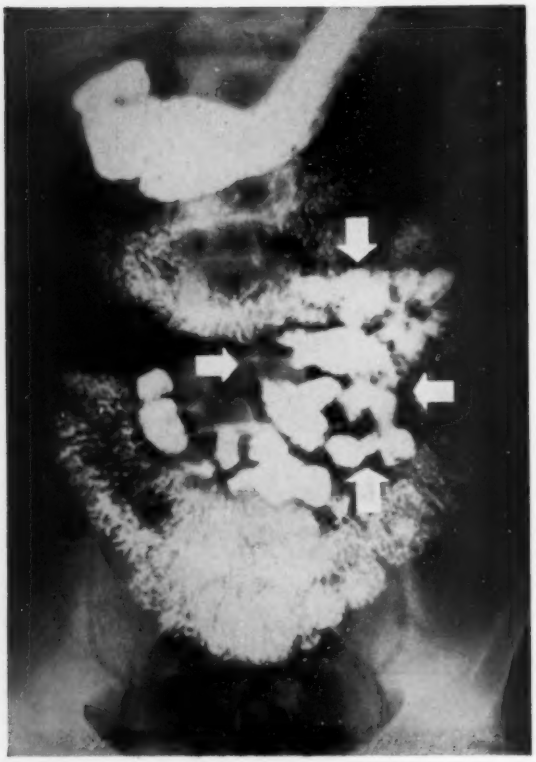

FIG. 13. (M. W.) Same case as Figure 12. Four weeks after successful anthelmintic therapy this roentgenogram, made almost immediately after the administration of the barium, shows a single group of severely distorted jejunal loops (arrows), in which segmentation and loss of mucosal folds is prominent. The remainder of the small intestine visible is practically normal. The red blood count was 3,500,000.

FIG. 14. (M. W.) Same case as Figure 13. Six weeks later (ten weeks after the first examination) this roentgenogram made at one-half hour shows an almost complete return to normal. There is still some coarsening of the mucosa. The red blood count was 3,900,000 at this time and the patient was clinically well.

Twenty-nine cases with abnormal small intestines were re-examined after successful anthelmintic therapy at intervals varying from five weeks to six months. Eighteen

of these patients had had minimal alterations, of whom 5 were normal and 5 showed improvement when re-examined. Eight showed no change, in spite of clinical cures.

Eleven of the patients re-examined had originally been found to have moderately or severely damaged small intestines. None of these returned to normal after therapy. Eight showed improvement and 3 showed no change. The tendency for return to normal was most marked in the type of change which predominated in the individual case. That is, if mucosal changes predominated, the return to normal was most marked in the mucosal pattern. The same held true if changes in the tunica muscularis were predominant.

The experience of others (Snell and Camp, Golden) with other causes of the deficiency pattern is thus confirmed. Severely distorted small intestines may return towards, but not to, the normal. Some cases with only minimal changes may exhibit *restitutio ad integrum*. The clinical improvement was more rapid and more marked than the roentgenologic improvement.

Fig. 15. (E. E.) "Hookworm disease." Roentgenogram made at one and one-half hours shows some break up in the barium column with segmentation (arrows) and hypermotility. The mucosal pattern is relatively normal.

Fig. 16. (E. E.) Same case as Figure 15. Nine weeks after successful anthelmintic therapy and a remarkable clinical recovery, there is practically no improvement in this one and one-half hour roentgenogram. This patient had had the ground itch on many occasions as a child, and it is possible that the changes seen represent the end stage of a remote infestation.

MECHANISM

Golden discussed the possible physiologic mechanisms involved in the production of the "deficiency pattern." He pointed out that the diversity of causes suggested that some common mechanism must be involved, and that, inasmuch as the intramural nervous systems controls, or at least influences, the intestinal movements, it might well be the common factor. The similarity of the changes in the small intestine which we have encountered in this study to those

of the deficiency pattern indicates that in this instance also some systemic mechanism is called into play.

The actual physical presence of the hookworm in the lumen of the small intestine is probably not the determining factor, since no other reported cause of the deficiency pattern possesses this factor. Furthermore we have observed similar changes in 2 cases of *Trichuris trichiura* and 1 each of *Hymenolepis nana* and *Ascaris* infection.

Anemia is probably not the cause, since very few patients had severe anemia, and there was no constant correlation between the degree of anemia and the extent of the changes in the small intestine. Hypoproteinemia (as a result of chronic blood loss) could not be excluded since we were unable to have quantitative protein determinations done, but no patient had edema.

The possibility of an exotoxin must be considered but no evidence has been produced to date to indicate that the hookworm produces such an exotoxin.

It is probable that the absorption of certain essential dietary factors is interfered with as a result of the damage done to the small intestine by the hookworm. It would have been of considerable interest to administer liver extract parenterally before beginning anthelmintic therapy. A return to the normal pattern under such parenteral therapy would have definitely established the evidence of a deficiency, due to the hookworm, as the cause of the abnormal small intestinal pattern. Unfortunately this could not be done. Considerable pressure existed to return these men to duty as soon as possible, and a delay of some weeks before beginning anthelmintic therapy could not be allowed. It is hoped that at some time in the future this aspect of the problem can be investigated.

SUMMARY AND CONCLUSIONS

1. Certain alterations in the small intestinal pattern have been described in a number of clinical entities under the term "deficiency pattern." This report indicates that infestation with the hookworm, *Necator americanus*, causes this same alteration in the physiology of the small intestine. Therefore, when the deficiency pattern is seen, the patient's stools should always be examined for the ova of intestinal parasites.

2. Complete small intestinal studies were made on 97 young adult, white males known to harbor the *Necator americanus*, and who had no other disease known to cause the deficiency pattern. Of the 44 cases of clinically significant "hookworm disease," 40 showed abnormalities of the small intestinal pattern, 26 of which were moderately or far advanced. Of the 53 cases of asymptomatic incidental "hookworm infestation," 33 had a normal small intestine, 16 showed minimal variations from the normal and only 4 had severe alterations of the normal pattern.

3. After anthelmintic therapy alone, there was a return towards, but not to, the normal pattern, in severe cases. Minimal alterations disappeared entirely in some instances.

4. A significant correlation exists between the presence and extent of the physiologic alterations seen on the roentgenograms, the clinical findings and the severity of the infestation with the hookworm.

5. The pathogenesis of these changes is still obscure.*

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* Since this article was written a report by A. McKenzie (Deficiency of vitamin B_1 in hookworm anaemia, *Lancet*, 1939, *1*, 1143–1145) has come to our attention. In treatment of the anemia of hookworm disease McKenzie found that simple iron preparations were the most efficacious, but that the edema present in his severe cases yielded only to large doses of vitamin B_1 given parenterally. A generous diet had not proved curative, and brewers' yeast had yielded only slight improvement, indicating that impaired absorption was the most probable explanation. This treatment was carried out before anthelmintic therapy.

The patients had been on the standard diet supplied estate workers in East Africa. Other workers not infested with the hookworm showed no such deficiency.

This report of improvement of clinical symptoms confirms our opinion that the changes visible roentgenologically are actually, in large part, a "deficiency pattern."

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DISCUSSION

MAJOR ROBERT C. PENDERGRASS, White Sulphur Springs, W. Va. I am delighted to have heard the presentation this morning, because since 1928 I have practiced radiology in a section where hookworm infestation is severe and during all these years I have missed the really significant changes occurring in these cases. We have observed in a great many of these cases marked irritability with reflux of the barium stream into the duodenum, but, unfortunately, no attention was paid to the small bowel pattern. I trust that this paper will not simply go on record as adding another causative factor to the deficiency pattern in the small bowel, but that it will be regarded as of clinical importance.

We have for a number of years in the South seen patients with vague abdominal complaints who have been diagnosed everything from peptic ulcer to chronic appendicitis, in whom hookworm has been found and whose symptoms have cleared up following treatment. With another sign of possible hookworm infestation added to our roentgenographic armamentarium, we should certainly bear in mind, when we see this pattern, that the patient may have such an infestation.

I should like to add one other brief remark. Major Krause stated that as a rule the ova disappear within six or seven years after the last infestation. We know from clinical experience that that is not always true and I have seen ova in adults as old as forty and forty-five years with symptoms of hookworm infestation.

There is one other point I should like to mention and that is that since *Necator americanus* inhabits chiefly the jejunum, we may begin to see within the next few years the tropical type of hookworm, since our troops are going into all sorts of climates and into all sorts of locations and some of these men may come back with infestation with the tropical type of hookworm, and it may be that then we will see roentgenological manifestations of disturbance of the duodenum rather than the jejunum.

I certainly wish to commend Major Krause for his careful study. It requires unusual zeal to carry out such a detailed investigation in addition to the routine work required in a large Army hospital.

DR. ROSS GOLDEN, New York, N. Y. We are to be congratulated on the opportunity to hear this excellent presentation. It is important, not only because Major Krause has shown that disturbances in the intestine caused by hookworm may be demonstrated by roentgenologic methods, but because further study may throw additional light on the mechanism of other intestinal disturbances. To this end it would be interesting to have information about the exact nature of the local lesions at the site of attachment of the worms to the wall. Major Krause, if I understood his statement correctly, was inclined to question whether there was a local disturbance due to the presence of the worm. It seems possible to me that there may be two factors concerned in this, one of which is local and the other general, such as a nutritional disturbance. Major Krause was not able to have serum protein examinations made in these cases but we know that a hypoproteinemia may be associated with severe anemia such as some of these patients had and that is one thing which can cause a profound disturbance in intestinal physiology.

In regard to the possibility of a local disturbance, his first slide showed a case in which there was only one loop of jejunum which was abnormal, and in that the mucosal folds were definitely widened and coarsened in marked contrast to the appearance of the other loops. That to me would suggest the possibility that it was

due to a local rather than to a general effect such as might result from a nutritional disturbance or a hypoproteinemia. In this connection I should like to show you one case for which I am indebted to Dr. R. R. Newell of San Francisco. This patient had generalized amyloidosis and, at autopsy, amyloid deposits were present in the wall of the small intestine. The films showed a widening, coarsening and irregularity in the mucosal folds of the jejunum which is very similar to that demonstrated by Major Krause in the above mentioned case. This, of course, does not prove that the amyloidosis of the wall was responsible for the abnormal appearance but it is highly suggestive.

In addition to the scientific importance of these observations, Major Krause has helped the Army in getting some of these soldiers back to duty. He did not have time to bring out the fact that some of them were poor soldiers until the presence of real organic disease was demonstrated and proper treatment was instituted. I hope that Major Krause will have an opportunity some time to correlate the roentgen findings in these cases with the histologic picture of the intestinal wall.

These writers are to be congratulated on this important contribution.

MAJOR KRAUSE (closing). I should like to thank Major Pendergrass and Dr. Golden for their pertinent discussion. As Major Pendergrass brought out, those of us who have practiced in the northern half of the United States have never had to worry about intestinal parasites in our daily practice; but there are lots of northern boys in strange lands these days and they may bring back unfamiliar illnesses.

The question of the local action of the hookworm cannot be denied. However, we were inclined to minimize it somewhat, because with few exceptions, as in Figure 4, the changes were generalized throughout the small intestine. Dr. Strong, in his well known book on tropical diseases, indicates that almost all of the hookworms are localized in a relatively short portion of the gastrointestinal tract, namely, the middle third of the small intestine. It was therefore a little difficult for us to attribute these changes to local factors, but such factors must be considered and probably do form a part of the picture.

I was unable to have total serum protein determinations done, but no patient had edema and only three had red blood cell counts under two and one-half million. Only a handful of them were under three and one-half million. Otherwise all the rest of the patients had a high enough red cell count to eliminate clinically the probability of hypoproteinemia.

Vol. 49, No. 6

ROENTGENOGRAPHIC OBSTETRICAL PELVICEPHALOMETRY IN THE ERECT POSTURE*

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A METHOD of roentgen pelvimetry and of fetal cephalometry was described by one of us (R.P.B.)[1,2,3] which involved the determination of the volume of the fetal head from circumference measurements taken from right angle (anteroposterior and lateral) views. For a time the films were taken with the patient horizontal on the Potter-Bucky diaphragm table. For over five years the erect position has been used for this purpose in order to eliminate the possibility of a change in the relation of the uterus to the axis of the maternal body when the patient is turned from the anteroposterior to the lateral position. With the patient standing before an upright Potter-Bucky diaphragm the effect of gravity on the uterus and its contents is the same in both positions and the possibility of shift in the position of the fetal skull with the change in the position of the mother is eliminated.

It is the purpose of this paper (1) to describe the technique used in making the roentgenograms, and (2) to discuss their interpretation with particular reference to the quantitative relationship between the size of the fetal cranium and the maternal bony pelvis.

Two interesting by-products of the erect position observed with cephalic presentation which will be discussed below are (1) the "engagement" of the fetal head in the pelvic inlet through the pull of gravity, and (2) the displacement of the head by masses in the pelvis.

TECHNIQUE

Size 14 × 17 inch films are used in a vertical Potter-Bucky diaphragm. The long axis of the films is placed horizontal for anteroposterior views and vertical for the lateral view. A 36 inch anode-film distance is preferred, although other distances may be used.

Lateral View. The lateral view is taken first because of the convenience of external landmarks which can be used in alignment. The first step in this exposure is to align the patient with the film. The lower border of the film should be placed on a level with the gluteofemoral crease. The posterior border of the sacrum should be about 1 inch inside the lateral border of the film (Fig. 1). The second step in the lateral view is to center the roentgen tube. The central rays should pass through the posterosuperior margin of the acetabulum. A convenient external landmark for this point is about 1 inch above the superior margin of the greater trochanter. For the average size patient about 85 kv. and 400 ma-sec. will be required, using "par speed" screens, to obtain a good quality roentgenogram. Accurate centering will result in the practical superimposition of one sacrosciatic notch upon the other.

Anteroposterior View. For this view the height of the Potter-Bucky diaphragm and of the roentgen tube remain the same as for the lateral view. The patient turns at right angles to face the roentgen tube and is then placed with the midsagittal plane of the pelvis in the median plane of the film. The roentgen tube should be moved horizontally so that the central rays will pass through the median plane of the pelvis. The central rays will pass very near the superior margin of the symphysis pubis in this position (Fig. 2). The average patient will require 85 kv. and 200 ma–sec. exposure, using "par speed" screens, for good quality roentgenograms, but the exposure factors (ma-sec.) will be more variable than in the

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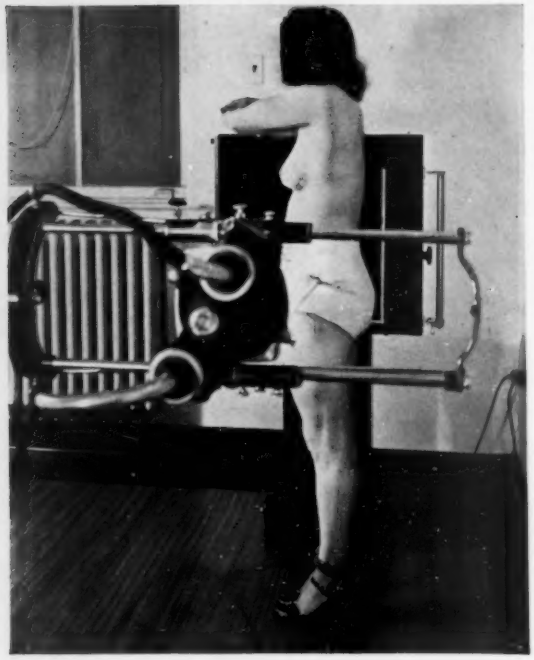

FIG. 1. Position of the patient for a lateral view of the pelvis in obstetrical roentgenography. The lower border of the film is on a level with the gluteofemoral fold. The sacrum is about 1 inch inside the lateral border of the film. The central rays are directed through the posterosuperior border of the hip joint. It is well to have the anode up and turned anteriorly to obtain the "bell effect" of the tube through the thickest part of the pelvis. The photograph shows the anode up but turned in the wrong direction.

lateral view, depending upon how pendulous the abdomen is or the quantity of amniotic fluid present.

To get a stereoscopic pair, a second roentgenogram may be made in the anteroposterior position with the tube shifted higher (3 inches for a 36 inch target-film distance). The first film, of course, is used for the measurements described below. If the abdomen is unusually pendulous or large, the second anteroposterior view in the erect posture can be omitted and stereoscopic roentgenograms taken with the patient supine. In the supine position, there will be less superimposed fluid and soft tissue present to interfere with good bone detail.

Breech Presentation. In a breech presentation an additional roentgenogram is made in the anteroposterior and also in the lateral view with the patient standing. These views are not taken until after the usual roentgenograms of the pelvis are developed and inspected, from which the level of the fetal head can be determined. The exposures are then made with size 14 × 17 inch films placed with the long axis horizontal and the central rays passing through the midcoronal and midsagittal planes of the body at the level of the fetal head. These exposures require about 85 kv. and 100 ma-sec., using "par speed" screens.

A filter heavier than those ordinarily used is desirable. We have found 5 mm. Al or 0.12 mm. Cu (0.001 in.) satisfactory with very little increase in exposure time.

INTERPRETATION OF THE ROENTGENOGRAM

When roentgenograms are taken with the patient standing, the fetus lies in the lower-

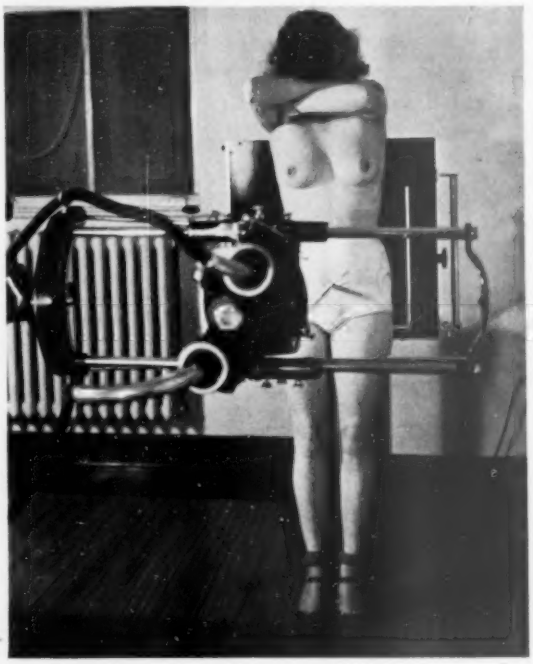

FIG. 2. Photograph showing the position of the patient for the anteroposterior view of the pelvis in obstetrical roentgenography. The vertical Potter-Bucky diaphragm remains at the same height. The tube height is unchanged. The central rays pass through the pelvis about 1 inch above the symphysis pubis. A vertical shift is used for a second exposure to obtain stereoscopic films.

most portion of the amniotic sac. About 95 per cent are found in cephalic presentation. With this presentation, the most dependent part of the fetal cranium will lie nearly as low as the ischial spines in many cases. Others will show the fetal head dipping well into the pelvic inlet, except in a few instances. The exceptions are the ones most likely to have either soft tissue or bony dystocia. Even though the fetal head is not dipping below the pelvic inlet, it should be found normally in the median plane of the abdomen as seen in the anteroposterior view and in the midcoronal plane of the pelvic inlet as seen in the lateral view. When the head is found displaced laterally or anteroposteriorly a distance equal to about one-third the diameter of the cranium and not dipping into the pelvic inlet, the presence of a soft tissue mass holding the head out of the pelvis is suggested. The mass could be an ovarian cyst, a fibroid, an overdistended urinary bladder or sigmoid and, most important, it may be a low implantation of the placenta (placenta praevia[4]). In multiple pregnancies or breech presentations, the presenting part will not necessarily be found normally in the median plane of the pelvis.

During the exposure of roentgenograms taken in the manner described above, the fetal head and cardinal diameters of the pelvis are very nearly the same distances from the anode and from the film, consequently the magnification factor is very nearly the same for the fetal head and transverse pelvic diameters in the anteroposterior view as well as for the fetal head and the anteroposterior diameters in the lateral view. This spatial relationship makes it possible to utilize the fetal head for a "yardstick" in estimating fetal head-maternal pelvis ratio. The comparison can be made from flat films or stereoscopic roentgenograms. It is much preferable to have the fetal head shadow in close proximity to the pelvic diameters through which the fetus is to pass, as occurs in the erect position, rather than to make a stereoscopic comparison between the pelvis and the shadow of the fetal head lying high as it does in the horizontal posture. As stated previously, roentgenograms taken in the erect posture will permit this comparison in the majority of obstetrical cases examined in the last four to six weeks of pregnancy. Also observations on pelvic shape, prominence of the ischial spines and inclination of the sacrum can, of course, be made from the roentgenograms taken in the erect posture. For classification of the pelvic inlet according to the scheme of Caldwell and Moloy[5], a stereoscopic view as described above is necessary.

MENSURATION

Roentgenographic mensuration of the fetal head and maternal pelvis may be of practical clinical aid in some instances. Pelvic measurements should not be overemphasized since many factors enter into an obstetrical delivery. A relatively small fetal head in a large pelvis does not necessarily indicate an easy obstetrical delivery. Soft tissue dystocia, uterine inertia, malpresentation, and other factors may present a difficult obstetrical problem when the spatial relationship between the fetal head and maternal pelvis shows that no bony dystocia is present. Nevertheless, a comparison of the size of the fetal head with the dimensions of the maternal pelvis in quantitative units may serve a useful purpose in statistical analyses. An analysis of a large series of patients may reveal factors not heretofore appreciated. A report of this type of analysis will be the subject of a subsequent paper. The method which has been used to compute the measurements will be described in this report.

The roentgenograms taken in the anteroposterior and the lateral projection in the erect posture, as described above, are marked with a china pencil in the manner shown in Figures 3 and 4. The pelvic diameters in Figure 3 are all in the midsagittal (median) plane of the pelvis. They have the same magnification factor for that reason. A computation of the magnification would be a laborious process unless one used some type of nomogram. A previously described nomo-

FIG. 3. Lateral roentgenogram of the pelvis taken with the obstetrical patient standing erect. The fetal head passes far down into the pelvis to the level of the ischial spines, showing at a glance that engagement occurs without difficulty. The lettered internal pelvic dimensions are measured and their magnification corrected (see text) to obtain the spatial relationship between the fetal head and pelvis. All of the dimensions shown are in the median plane of the pelvis. *tt* is a line parallel to the film border passing through the most prominent posterior border of the sacrum and may be used to represent the Potter-Bucky diaphragm surface for obtaining the object-film distance which is necessary for correction of the transverse diameters shown in Figure 4 (see Fig. 7 and text). Not all of the dimensions indicated here are necessary for clinical pelvimetry at the present time. The report routinely includes *B* (anteroposterior diameter at the inlet), *D* (the median anteroposterior diameter of the fore pelvis, i.e., the distance from the plane of the ischial spines to the symphysis pubis), and *E* (the same diameter of the posterior pelvis, i.e., from the plane of the ischial spines to the sacral tip). The other dimensions are useful for anthropological study and statistical analysis.

gram,[7] used by the authors, has proved to be satisfactory for this purpose. It has four plotted scales and a central transfer axis (Fig. 5). The scales are printed on a rigid board, while the transfer axis is replaced by a slot in the board. This permits

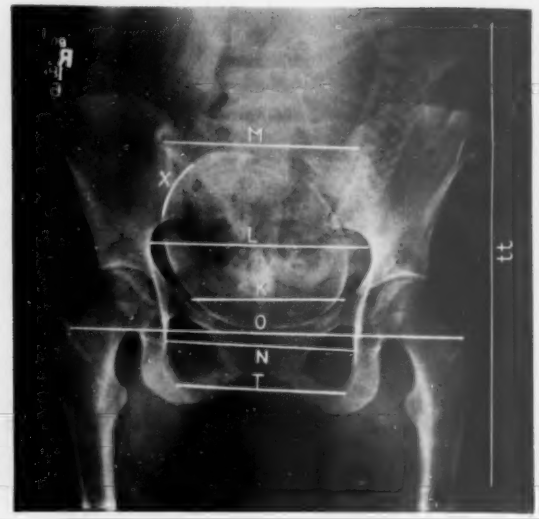

FIG. 4. Anteroposterior roentgenogram of the obstetrical patient taken standing. The fetal head lies in the center of the pelvis. The lettered transverse dimensions are defined in the text. At the present time only diameters *L*, *K*, *N*, and *T* are given in a routine pelvimetry report. *tt* is a vertical line passing 2 cm. lateral to the medial border of the greater trochanter when 36 inch anode-film distance is used and represents the table top for roentgenographic mensuration.

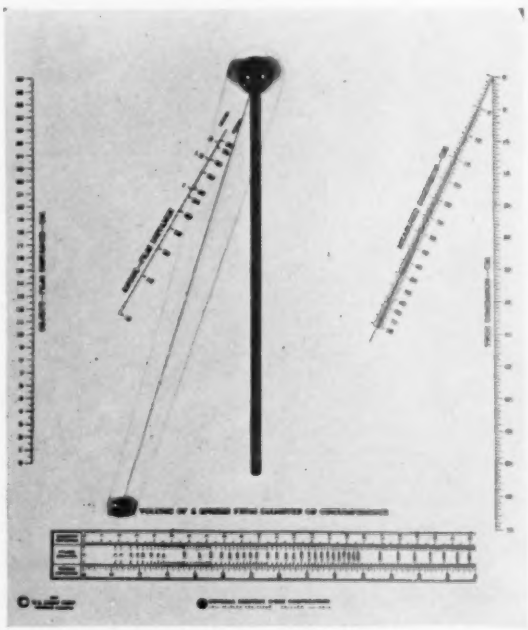

FIG. 5. Photograph of a nomogram (calculator) used to correct for magnification of film image in obstetrical pelvicephalometry. See text.

a transparent arm containing a hair line to be pivoted at the proper point for correcting the magnification on the film image. The movable arm is first placed on the points of the scales showing object-film distance and anode-film distance. A knurled knob over the pivot point is tightened and the arm is then swung over the scale marked "measured dimension." The corrected (true) dimension is then read from the point of intersection of the hair line in the movable arm with the scale marked "true dimension." By the use of the nomogram, the correction of film-image magnifications can be done rapidly and without any mathematical computation. A chart (Fig. 6) on the board gives the volume of a sphere of known circumference or diameter so that the fetal head may be compared with pelvic diameters in terms of volume and volume capacity respectively.

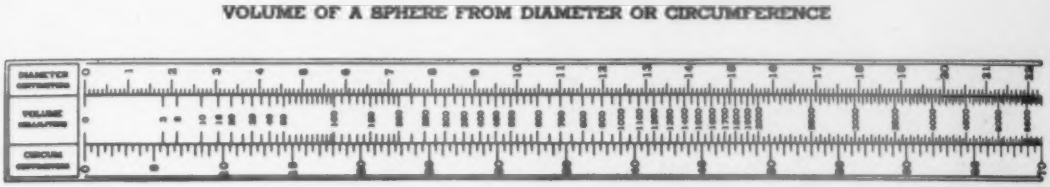

Fig. 6. A chart showing the volume of a sphere from either a circumference or diameter measurement. It is convenient for translating a measurement of a sphere into units of volume.

The pelvic dimensions (diameters) shown in Figure 3 may be defined as follows:

A. Symphysis pubis to tip of sacrum.
B. Symphysis pubis to sacral promontory.
C. Sacral promontory to sacral tip. Vertical height of sacrum.
D. Median anteroposterior diameter of the fore pelvis. Symphysis pubis to median plane of biischial spine diameter.
E. Median anteroposterior diameter of the posterior pelvis. Sacral tip to median plane of biischial spine diameter.
F. Symphysis pubis to third sacral segment.
H. Sacral promontory to median plane of biischial tuberosities.
Vertical height of pelvis.
P. Symphysis pubis to median plane of biischial tuberosities.
Q. Sacral tip to median plane of biischial tuberosities.

All of these pelvic dimensions are in the median plane of the pelvis and consequently are located equal distances from the anode and film when the roentgenogram is exposed. In other words, the magnification factor is the same for all these dimensions. To correct magnification, it is necessary to know the object-film distance (the pelvic dimension is the object) and the anode-film distance. It is easy enough to select a convenient anode-film distance. In our experience a 36 inch anode-film distance has been found to be very satisfactory. The object-film distance will be the distance from the median plane of the pelvis to the film. Obviously this could be easily measured on the patient by taking one-half the bitrochanteric diameter and adding it to the distance from the surface of the Potter-Bucky diaphragm to the film. Since it is not always convenient for the roentgenologist to make the bitrochanteric diameter measurement on the patient, the technician can take this measurement with the technique rule when the patient is posed for the lateral view, or can measure the distance from the center of the sacrum (the line of the spines of the sacral segments) to the diaphragm surface.

The distance of the median plane of the pelvis from the surface of the erect Potter-Bucky diaphragm (hereinafter called the "diaphragm surface") when the lateral view is exposed, can be estimated also from the anteroposterior view. In Figure 4, *O* is the distance from the inner border of one greater trochanter to the other. With a 36 inch anode-film distance, 4 cm. should be added to the dimension *O* to obtain the approximate bitrochanteric diameter of the patient.

At 30 inch anode-film distance, 2 cm. should be added to the measurement of *O* obtained from the anteroposterior view. One-half of the resulting figure gives approximately the distance of the median sagittal plane of the pelvis from the diaphragm surface. The figures obtained in this way may be a little larger or a little smaller than those obtained with the technique rule as described above, but the variation in the results of the two methods is usually under 0.5 cm. and is rarely over 1.0 cm., which produces a negligible difference in the corrected pelvic measurement. For example, a 2 cm. difference in the determination of the intertrochanteric distance makes a change of 1 cm. in the distance of the median plane of the pelvis from the film which, in turn, produces only about 1 mm. difference in the corrected measurements of the diameters in the sagittal plane of the pelvis, which is obviously unimportant. The reason for this difference in the results of the two methods probably lies in the different amounts of adipose tissue lying lateral to the greater trochanter in different individuals.

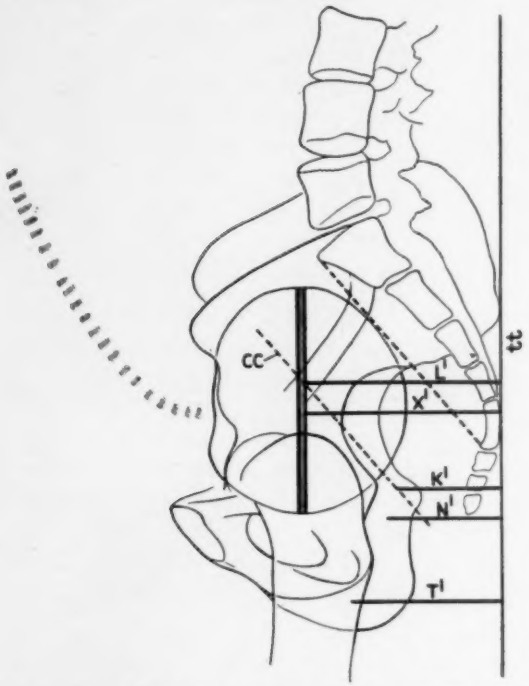

FIG. 7. Tracing of roentgenogram shown in Figure 3. The letters marked prime indicate the object-table top distances of the transverse dimensions shown in Figure 4 used in correcting the measurements. In this instance, the distance from the table top (*tt*) of the greatest transverse diameter of the inlet (*L'*) happens to be practically the same as that (*X'*) of the central vertical transverse plane of the fetal head in the anteroposterior view.

One-half of the bitrochanteric diameter, as previously stated, is the object-diaphragm surface distance. The distance from the diaphragm surface to the film is a constant which varies only with the particular Potter-Bucky diaphragm and make of the apparatus. The diaphragm surface-film distance plus the object-diaphragm surface distance is, of course, the object-film distance. The correction of the measurements of the dimensions shown in Figure 3 is then made by placing the movable arm of the nomogram over the appropriate points on the two scales to left, shown in Figure 5, tightening the knurled knob over the slot and then swinging the movable arm around to where it intersects the scale of measured dimension. The corrected dimension is read from the point of intersection of the hair line in the movable arm on the scale of true dimension.

The pelvic dimensions shown on the anteroposterior view (Fig. 4) may be defined as follows:

M. Greatest width of the sacrum.
L. Greatest transverse diameter of the pelvic inlet.
K. Biischial spine or interspinous diameter.
O. Inner bitrochanteric diameter.
N. Biischial diameter taken at level of inferior borders of ischial spines.
T. Biischial diameter taken at lowermost point of ischial tuberosities (base of subpubic arch).

The object-diaphragm surface distances of these pelvic dimensions may be very closely estimated from the lateral roentgenogram. A line, *tt*—Fig. 3, is drawn parallel to the film border and passing through the most posterior prominence of the sacrum. This line may represent the diaphragm surface. To obtain the object-diaphragm sur-

face distance of the biischial spine diameter (Fig. 4, *K*), the distance from the biischial spines to *tt* in Figure 3 is measured. The total object-film distance will of course be this measurement plus the diaphragm surface-film distance. The corrected dimension of the biischial spine diameter is then obtained by use of the nomogram. A graphic summary of the points used to obtain the object-diaphragm surface distances of the transverse pelvic dimensions is shown in Figure 7. Similarly the points of measurement for object-diaphragm surface distances of the dimensions in the median plane of the pelvis are shown in Figure 8.

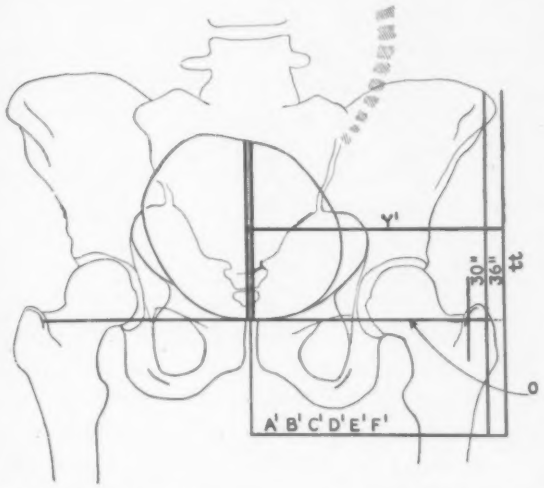

FIG. 8. Tracing of roentgenogram shown in Figure 4. The prime letters indicate the object-table top distance of the dimensions shown in Figure 3. See text for description of method of measurement.

The points of measurement of the greatest transverse diameter of the pelvic inlet should be explained in detail. In the anteroposterior view, it will obviously be the greatest horizontal diameter of the inlet (Fig. 4, *L*). In order to locate this point in the lateral view, to obtain its distance from the diaphragm surface, a line is drawn parallel to *C* (Fig. 3) passing through the ischial spines. This line is labelled *cc* in Figure 7. The point of intersection of *cc* with the iliopectineal line is the point of the greatest transverse diameter of the inlet regardless of the shape of the pelvis. We have examined a large series of articulated pelves and checked this observation in stereoscopic views. The greatest variation has not been over 0.5 cm. in any pelvis examined.

The usual reference to the size of the fetal head, in American literature, is in terms of cardinal diameters such as the suboccipitobregmatic, occipitofrontal, bitemporal, biparietal, etc. For purposes of roentgenographic mensuration it is believed that a more accurate estimate of the total size of the fetal cranium can be made from circumference measurements of the fetal cranial image. A diameter measurement may be foreshortened when lying in an oblique position in reference to the central ray. Furthermore, it is not always easy definitely to locate end points, even in stereoscopic views. When the mean circumference measurement of the fetal cranial image is made from right angle views (anteroposterior and lateral), the total volume of the cranium can be calculated. The perimeter of the cranial image is easily located and can be traced and measured in centimeters with a map measure.

In order to correct for the magnification of the fetal skull image perimeter measurement, the object-diaphragm surface distance is obtained from the roentgenogram taken at right angles. The image in the anteroposterior view (Fig. 4, *X*) is equivalent to a cross section taken in a vertical plane represented by a heavy striated line in Figure 7. The object-diaphragm surface distance is represented by *X'* in Figure 7. Thus, the circumference measurement is corrected in a manner similar to that used in correcting the pelvic dimensions as obtained from the roentgenographic image. The object-diaphragm surface distance for the cranial image in the lateral view is shown in Figure 8, *y'*.

The volume of the scalp of the fetus near term is about one-fifth the total volume of the cranium. Allowance should be made for this in estimating the total volume of the fetal cranium. The average thickness of the scalp of the newborn is about 3 mm. This

would add 6 mm. to the diameter of the bony cranium as obtained from the mean corrected measurements of the film images. Since the ratio of the diameter to the circumference of a circle is pi, 3.1416 × 0.6 cm. gives the difference between the circumference of the bony cranium and that of the surface of the scalp; therefore, the scalp volume is included in the estimate of the fetal cranium by adding 2 cm. to the mean circumference measurements of the skull. Figure 6 is a chart showing the volume of the sphere from circumference measurements.

It should be emphasized that the mean (average) measurement of the fetal cranium is made from the corrected measurements since the object-diaphragm surface distances may be different in the two views. Parenthetically, it may be added that one should not forget to add 2 cm. to the mean measurement to include the scalp.

FETAL CRANIAL MEASUREMENTS IN BREECH PRESENTATIONS

In a breech presentation the fetal cranial image is not close enough to the pelvic inlet to make an accurate comparison of size. However, the circumference of the fetal cranium can be measured in right angle views and the mean measurement, plus 2 cm. for scalp allowance, can be compared with the volume capacity of pelvic diameters. The cranial measurements are made from roentgenograms taken with the central ray passing through the body of the mother at or near the level of the fetal head as described under technique. The measurements and computation are the same as described for a cephalic presentation except that the object-diaphragm surface distances are obtained from different points. The only difference is that the line is extended up from the sacrum in the lateral view to obtain the object-diaphragm surface distance for the image measured in the anteroposterior view. Similarly the line is extended up from the inner border of the greater trochanter in the anteroposterior view to obtain the object-diaphragm surface distance of the image measured in the lateral view. The standing position of the patient eliminates shifts of the fetus between exposures except for the rare instance of an active fetal movement.

DISCUSSION

The erect posture is preferable to any other position for a roentgenographic examination of the obstetrical patient. Because of the effect of gravity, the fetal head will usually be found dipping into the pelvis and thereby permit a good visual estimation of the spatial relationship between the fetal head and bony pelvis. In cases of cephalic presentation, the normal position of the head in the midcoronal and median planes permits the recognition of soft tissue dystocia or placenta praevia when found displaced from the normal position. Roentgenograms taken with the patient erect are more satisfactory for mensuration than when taken in any other position. The erect posture is more pleasant and more comfortable to the patient near term.

The measurements described above are useful (1) for the purpose of clinical obstetrics, to aid in determining possible difficulty in delivery, and (2) for the purpose of anthropological study and statistical analysis.

For clinical purposes some of the diameters mentioned above are of no immediate significance. It has become our custom in writing reports to give the following diameters: anteroposterior (*B*) and transverse of the inlet (*L*), interspinous (*K*), intertuberous (*N*), base of the subpubic arch (*T*), sagittal diameter of the fore pelvis (*D*), and of the posterior pelvis (*E*). Obviously from the obstetrical standpoint, the three most important diameters are the anteroposterior and transverse of the inlet and the interspinous. The report includes a description of the shape of the inlet, using the terms recommended by Caldwell and Moloy, of the shape of the sacrum, of the type of sacrosciatic notches (male or female) and whether wide or narrow, of the side walls of the pelvis, i.e.,

whether straight or converging, and of the subpubic arch, i.e., whether wide or narrow and whether the top is rounded or sharp. The description of the shape of the subpubic arch is based largely on a roentgenogram taken with the tube angled 45 degrees upward through the pubis, as described by Caldwell, Moloy and Swenson;[6] the width of the base of this arch is reflected in the subpubic arch measurement, which, however, does not indicate the character of its top. The measurements of the inlet by themselves do not necessarily indicate its ability to transmit the fetal head but must be considered in conjunction with its shape; a small well rounded inlet (gynecoid type) may give no trouble while if the widest point of the inlet is placed farther back toward the sacrum (android type) great difficulty in engagement may be encountered.

The practical clinical application of quantitative studies of the pelvis and fetal head has been found useful. In any pelvis, the obstetrical conjugate *B* (Fig. 3) or the biischial spine diameter *K* (Fig. 4) will be the smallest internal pelvic diameter. However, in rare instances, these two diameters may be very nearly equal. If the mean circumference measurement of the fetal head plus scalp is translated into units of volume, milliliters, it can be compared to the volume capacity of one of these internal pelvic diameters, i.e., to the volume of the largest sphere which could pass through. (See Figure 6 for comparison of volume of a sphere determined from circumference measurements and from diameter measurements.) When the volume of the fetal head is less than the volume capacity of *either of these diameters*, there is no bony disproportion present. The volume of the fetal head can be larger than the volume capacity of either diameter without necessarily signifying the presence of important bony disproportion provided (1) that moulding of sufficient degree can occur thus reducing the size of the head in the direction of the narrow diameter, or (2) that compensatory space is present so that the widest portion of the fetal head does not have to pass through the narrowest diameter of the pelvis. Because of the variables involved namely (1) uterine force, (2) moulding, and (3) amount of compensatory space, arbitrary limits cannot be set. In general, however, the smaller the pelvis and the greater the difference between the volume of the fetal head and the volume capacity of the smallest pelvic dimension, the greater is the danger of serious difficulty in delivery and the more skill required of the obstetrician.

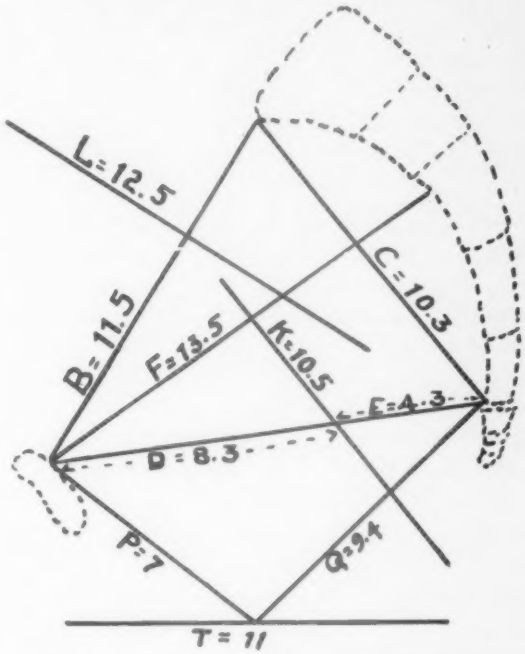

Fig. 9. A diagram showing the average in centimeters of the internal pelvic dimensions of 349 obstetrical patients. This diagram is useful for comparing any particular pelvis with an average. This type of diagram drawn to scale may be included in an obstetrical report to illustrate better the anatomical characteristics of the pelvis. At the present time our written reports include *B*, *L*, *K*, *T*, *D*, and *E*; the measurement *N* in Figure 4 is not indicated on this diagram.

The presence or absence of compensatory space can be ascertained by inspection of the roentgenograms, particularly in the stereoscopic views, or may be indicated by the measurements of other pelvic dimensions at the same approximate level. The

purpose, of course, is to obtain an idea of the cross section area. Reference to the average dimensions of certain internal pelvic diameters will quickly disclose wherein any particular pelvis differs from the average. Figure 9 is a diagrammatic representation of the average dimensions of 349 obstetrical patients examined in the Department of Radiology of the Presbyterian Hospital in New York City. In Figure 9, it will be noted that transverse dimensions are placed in such a manner as to be intersected by the median plane. This is merely a convenient manner of disclosing graphically certain anatomical characteristics of the pelvis. At the first inspection, the diagram may not have much meaning but, when one attempts to visualize the position and relative size of the transverse dimensions in relation to those in the median plane shown in the lateral view, it will appear logical. This type of diagram has been used in our reports and conveys both the actual pelvic dimensions drawn to scale and certain anatomical characteristics of the pelvis.

Pelvic diameters of no immediate clinical importance are of significance for anthropological studies and for statistical analysis. Indices may be obtained from certain dimensions which reflect pelvic shape and capacity. For example, an index can be obtained from the biischial spine diameter (K) and the sagittal diameter of the fore pelvis (D), called the D/K index. Let D (Fig. 3) be the numerator and K (Fig. 4) be the denominator of a fraction and multiply the result by 100. This represents a horizontal (with the patient erect) cross section of the pelvis at the level of the ischial spines with K as the base and D as the altitude of an elliptical periphery. Obviously an index of over 100 is produced when the altitude (anteroposterior diameter of fore pelvis) is greater than the base (interspinous diameter) of this cross section, and conversely an index of less than 100 is produced when the base is greater than the altitude. In a large series of obstetrical patients, the D/K index was found to average from 80 to 85. In a series of male pelves, the average D/K index was close to 96. A statistical analysis of pelvic dimensions and certain indices, correlated with fetal head size, pelvic type and the function of childbirth will be the subject of a subsequent report.

SUMMARY

The erect position has definite advantages for pelvicephalometry. Gravity does not change the position of the uterus when the patient turns from the anteroposterior to the lateral positions as it does when she is horizontal and hence true right angle views of the fetal head are obtained. In cephalic presentation, the fetal head will assume the lowermost position possible and is often found lying deep in the pelvis, showing that engagement takes place without difficulty. Failure of the head to dip into the pelvis and lateral displacement from the middle of the pelvis in the anteroposterior view, when the patient is near term, suggest the presence of a mass of some sort in the pelvis, possibly placenta praevia.

A method of mensuration of the maternal pelvis and fetal head, from roentgenograms taken in the erect posture, is described and certain pelvic dimensions are defined which are of importance for statistical analysis and for practical clinical purposes.

A diagram from the lateral projection to scale may serve a twofold purpose in reporting obstetrical cases. First, it gives a graphic representation of the particular pelvis and second, it permits a comparison with a normal average. In making a comparison it graphically discloses wherein a particular pelvis differs from another and shows the presence or absence of compensatory space in borderline cases.

Arbitrary limits of safety in pelvic dimensions cannot be set because of the variables involved in the function of childbirth (uterine force, amount of moulding, availability of compensatory space). As a general principle, however, it can be stated

that the smaller the pelvis and the greater the excess of fetal head volume over the volume-capacity of the smallest pelvic diameter, the greater the danger of difficulty. It is our impression that in borderline cases, the procedure described above serves much more frequently to show the obstetrician that engagement and delivery can probably occur than to aid him positively in deciding on elective cesarean section.

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ANALYSIS OF ROENTGEN PELVIMETRY BY THE JOHNSON STEREOROENTGENOMETER IN 379 CASES

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IN 1927, Johnson[4] described a practical method of stereoroentgenometry, similar in principle to the Mackenzie Davidson[3] method of opaque foreign body measurement and the Manges[7] modification of this original method for roentgen pelvimetry. As the result of subsequent improvements by Johnson,[5,6] this method is now accepted as one of the most popular and accurate methods of roentgen pelvimetry in use.

It was believed that it would be of interest to determine the average diameters of the pelvis and also to attempt to analyze the contracted diameters and the plane or planes in which they existed when correlated with the clinical course of the pregnancies.

This study includes the measurements of the pelvic diameters obtained in 450 consecutive obstetrical patients. With few exceptions, these individuals were primiparas. The principle of this method and the details of the technique have been described by Johnson.[4]

TABLE I

AVERAGE PELVIC DIAMETERS

	Cases Measured	Cases of Normal Deliveries Reported
Number of Cases	450	290
Inlet:		
Anteroposterior (true conjugate)	11.88 cm.	11.81 cm.
Transverse	13.56 cm.	13.65 cm.
Right oblique	12.92 cm.	13.03 cm.
Left oblique	12.92 cm.	13.06 cm.
Mid-plane (plane of least pelvic diameters):		
Anteroposterior	11.41 cm.	11.73 cm.
Transverse (interspinous)	10.30 cm.	10.44 cm.
Posterior sagittal	4.03 cm.	4.34 cm.
Outlet:		
Anteroposterior (to tip of sacrum)	11.41 cm.	11.73 cm.
Anteroposterior (to tip of coccyx)	9.51 cm.	9.52 cm.
Transverse	11.13 cm.	11.31 cm.
Posterior sagittal	7.09 cm.	7.47 cm
Fetal skull:		
Fronto-occipital	11.22 cm.	11.30 cm.
Suboccipitobregmatic	9.31 cm.	9.41 cm.

The average diameters of the 450 cases studied are shown in Table I. It will be noted that the averages obtained for this group of cases agree closely with those of Williams and of DeLee, with the exception of the true conjugate which is somewhat greater than the 11 cm. considered by these authors as normal. This consistent increase of the true conjugate of the pelvic inlet as determined by roentgen-ray measurements over clinical measurements has been noted by Rappaport and Scadron.[8]

It may be noted in Table II that of the 450 cases, 241, or 53.5 per cent, had pelvic diameters which were considered normal; 130, or 28.9 per cent, showed contraction in one or more diameters of from 5 to 10 mm.; and 79 cases, or 17.5 per cent, showed shortening in one or more diameters of more than 10 mm.

In an effort to correlate the value of this method of roentgen pelvimetry with clinical results, reports of the subsequent courses of the pregnancies were requested from the obstetricians referring the patients. In this manner it was possible to obtain information relative to the types of deliveries in 379 patients.

Analysis of the pelvic diameters obtained by stereoroentgenometry in these 379 cases

TABLE II

CLASSIFICATION OF CASES

Groups	450 Cases Measured		379 Cases Reported	
	No. of cases	Per cent	No. of cases	Per cent
Normal diameters	241	53.5	216	56.9
Cases in which one or more diameters were contracted from 5 to 10 mm.	130	28.9	95	25.1
Cases in which one or more diameters were contracted more than 10 mm.	79	17.5	68	17.9

(Table II) showed that in 216, or 56.9 per cent, all diameters were normal or greater than the accepted average diameters; in 95 patients, or 25.1 per cent, one or more diameters were shortened from 5 to 10 mm.; and in 68 cases, or 17.9 per cent, diameters were contracted over 10 mm.

Table III is a summary of the three groups of cases and the types of deliveries which occurred. Two hundred and ninety, or 76.5 per cent, of the entire group of 379 patients delivered normally. Seventy-two, or 18.9 per cent, had abnormal deliveries because of pelvic contraction or bony disproportion.

TABLE III

SUMMARY OF REPORTED CASES

Classification of Cases	No. of Cases Reported	Sections and Forceps Deliveries for Indications Other than Disproportion	Corrected No. of Cases	Normal Deliveries	Cesarean Sections	Forceps Deliveries	Difficult Deliveries	Early Induction
Normal measurements Per cent	216	11	205	203 99.0%	1 0.49%	1 0.49%	0	0
Cases in which one or more diameters were contracted from 5 to 10 mm. Per cent	95	4	91	73 80.2%	3 3.3%	8 8.8%	6 6.6%	1 1.0%
Cases in which one or more diameters were contracted more than 10 mm. Per cent	68	2	66	14 21.2%	47 71.2%	4 6.0%	1 1.5%	0
Total	379	17		290	51	13	7	1
Per cent (all cases)		4.5		76.5	13.4	3.4	1.8	0.3

Of these 72, 51, or 13.4 per cent, had cesarean sections; 13, or 3.4 per cent, had high or mid forceps deliveries; 7, or 1.8 per cent, had prolonged or difficult labors due to pelvic contraction; and in one case an early induction of labor was performed. The remaining 17 cases of this group had cesarean sections or forceps deliveries for indications other than bony disproportion. The average pelvic diameters of the 290 patients who had normal deliveries are shown in Table 1.

Table IV is a study of the 216 patients who had normal or greater than average measured diameters as determined by stereoroentgen pelvimetry. Of these, 203 delivered normally. Episiotomies and low forceps deliveries were considered normal for this study and are therefore included in this group, which, as was previously mentioned, consisted of primiparas with few exceptions. Three patients had forceps deliveries: 2 for indications other than bony disproportion, and in the remaining case an 8 pound, 5 ounce baby was delivered from a pelvis of average diameters (the fronto-occipital diameter of the skull measured 11.8 cm. several weeks before delivery). Ten cases were delivered by cesarean section: 1 because of placenta previa, 1 because of brow presentation, 1 because of rupture of the uterus, 6 because of cervical dystocia, and 1 because of apparent bony disproportion. The pelvic diameters of this last patient were not greater than the average (i.e., anteroposterior of the outlet 11.4 cm., interspinous 10.5 cm.) and the fetal skull measured 11.9 cm. in fronto-occipital diameter and 9.7 cm. in the suboccipitobregmatic diameter several weeks before delivery. If the 9 patients delivered by cesarean section and the 2 by forceps for indications other than bony disproportion are excluded from this group, there remain 205 patients with normal measurements, of which 203, or 99.0 per cent, delivered normally and 2, or 1 per cent, had abnormal deliveries. Therefore, it would appear that if the diameters obtained by the Johnson method of stereoroentgenometry are found to be normal, the accuracy of this method in the determination should be about 99 per cent.

TABLE IV

CASES IN WHICH THE PELVIC DIAMETERS WERE FOUND NORMAL OR GREATER THAN AVERAGE

No. of Cases Reported	Sections and Forceps Deliveries for Indications Other than Disproportion					Corrected No. of Cases	Normal Deliveries	Forceps Deliveries	Cesarean Sections
	Forceps	Cesarean sections							
	Posterior position	Brow presentation	Rupture of uterus	Cervical dystocia	Placenta previa				
216	2	1	1	6	1	205	203	1	1
Per cent							99.0	0.49	0.49

Table V is an analysis of the 95 patients who had one or more diameters shortened from 5 to 10 mm. The contracted diameters are listed to the left of the table. As would be expected in this group, in many cases there was sufficient increase in one or more of the other diameters to compensate for the moderately contracted diameter or diameters. Seventy-three patients, or 80.2 per cent, delivered normally; 3 cases, or 3.3 per cent, had cesarean section; 8, or 8.8 per cent, were delivered by forceps; 6, or 6.6 per cent, had unusually prolonged and difficult labor; and 1 had an early induction of labor. There were 3 cesarean sections and 1 forceps delivery in this group for indications other than bony disproportion.

TABLE V

CASES IN WHICH ONE OR MORE DIAMETERS WERE CONTRACTED FROM 5 TO 10 MM.

Plane of Pelvis in Which Contraction Existed						Indicated Because of Disproportion			Indications Other than Disproportion	
Inlet	Mid-plane	Outlet	No. cases	Normal deliveries	Difficult deliveries	Section	Forceps	Early induction	Section	Forceps
A.P.	Normal	Normal	1	1						
A.P.	Trans.	Normal	1						1	
A.P.	A.P.	A.P.	3	3						
Trans.	Normal	Normal	4	4						
Trans., R.O., L.O.	Normal	Normal	2	1	1					
Trans., R.O., L.O.	A.P.	A.P.	2	1		1				
Trans., R.O.	A.P., Trans.	A.P., Trans.	2			1	1			
Trans., R.O., L.O.	Trans.	Trans.	1	1						
Trans., R.O.	Trans.	Trans.	3	2		1				
Trans.	Trans.	Trans.	11	7			4			
Trans.	A.P., Trans.	A.P., Trans.	2	1				1		
Trans.	A.P., Trans.	A.P.	1	1						
Trans.	A.P.	A.P.	4	3	1					
Trans.	A.P.	A.P., Trans.	3	3						
Trans.	Trans.	Normal	6	5	1					
R.O., L.O.	A.P., Trans.	A.P., Trans.	1	1						
Trans.	Normal	Trans.	1				1			
R.O., L.O.	Normal	Normal	1	1						
R.O., L.O.	Normal	Trans.	1							1
R.O.	Trans.	Trans.	1	1						
L.O.	A.P.	A.P.	2	2						
L.O.	A.P., Trans.	A.P., Trans.	3	2	1					
Normal	A.P., Trans.	A.P.	6	4			1		1	
Normal	A.P., Trans.	A.P., Trans.	2	2						
Normal	A.P.	A.P.	11	11						
Normal	A.P.	A.P., Trans.	2	2						
Normal	Trans.	Normal	7	6					1	
Normal	Trans.	Trans.	8	5	2		1			
Normal	Normal	Trans.	3	3						
Total (all cases)			95	73	6	3	8	1	3	1
Total (excluding sections and forceps delivery for indications other than disproportion)			91	73	6	3	8	1		
Percentage				80.2	6.6	3.3	8.8	1.0		—

A.P. = anteroposterior; Trans. = transverse; R.O. = right oblique; L.O. = left oblique.

In Table VI are included the 68 patients in whom pelvimetry revealed one or more diameters shortened or contracted more than 10 mm. The contracted diameters are listed in the three columns to the left of the table. It will be noted that 47 patients, or

TABLE VI

CASES IN WHICH ONE OR MORE DIAMETERS WERE CONTRACTED MORE THAN 10 MM.

Plane of Pelvis in Which Contraction Existed						Indicated Because of Disproportion			Indications Other than Disproportion	
Inlet	Mid-plane	Outlet	No. cases	Normal delivery	Difficult delivery	Section	Forceps	Early induction	Section	Forceps
A.P.	A.P.	A.P.	1			1				
A.P., Trans., R.O., L.O.	A.P., Trans.	A.P., Trans.	1			1				
A.P., Trans., R.O., L.O.	A.P.	A.P.	1	1						
A.P., Trans.	A.P., Trans.	A.P., Trans.	2			2				
A.P., R.O. L.O.	A.P.	A.P.	2	1	1					
A.P.	A.P., Trans.	A.P., Trans.	2			2				
A.P., Trans.	Trans.	Trans.	1			1				
Trans., R.O. L.O.	A.P.	A.P.	1			1				
Trans., R.O., L.O.	A.P.	A.P., Trans.	1			1				
Trans., R.O., L.O.	A.P., Trans.	A.P., Trans.	5	2		2			1	
Trans., R.O., L.O.	A.P., Trans.	A.P.	1			1				
Trans., R.O., L.O.	Trans.	Trans.	3			3				
Trans., R.O.	Trans.	Trans.	1			1				
Trans., L.O.	A.P., Trans.	A.P., Trans.	2	1		1				
Trans., L.O.	Trans.	Normal	1			1				
Trans.	A.P., Trans.	A.P., Trans.	5			4	1			
Trans.	Trans.	Trans.	7			6	1			
Trans.	Trans.	Normal	1			1				
Trans.	A.P., Trans.	A.P.	2			2				
Trans.	A.P.	A.P.	2	1					1	
Trans., R.O.	A.P.	A.P.	1			1				
R.O., L.O.	A.P.	A.P.	2			2				
R.O.	A.P.	A.P.	1			1				
L.O.	A.P.	A.P.	1			1				
R.O.	Trans.	Trans.	2			2				
R.O., L.O.	A.P.	A.P., Trans.	1			1				
Normal	A.P., Trans.	A.P.	1			1				
Normal	A.P., Trans.	A.P., Trans.	2			2				
Normal	Trans.	Trans.	6			5	1			
Normal	A.P.	A.P.	7	7						
Normal	A.P.	A.P., Trans.	2	1			1			
Total (all cases)			68	14	1	47	4	0	2	0
Total (excluding sections for indications other than disproportion)			66	14	1	47	4			
Percentage				21.2	1.5	71.2	6.0			

A.P. = anteroposterior; Trans. = transverse; R.O. = right oblique; L.O. = left oblique.

71.2 per cent, were delivered by cesarean section and that 4, or 6.0 per cent, had deliveries by forceps. Fourteen, or 21.2 per cent, delivered normally while 1 case had a prolonged and difficult labor. Two patients were delivered by cesarean section for indications other than pelvic contracture. It is of interest that this group includes 7 cases with contraction of over 10 mm. of the interspinous diameter of over 10 mm., only 3, or 6.6 per cent, delivered normally. Thirty-eight, or 84.4 per cent, were delivered by cesarean section while 3 patients, or 6.6 per cent, had forceps deliveries.

For the purpose of pelvimetry the pelvis may be divided into three planes. These are the inlet or superior strait, the mid-plane or

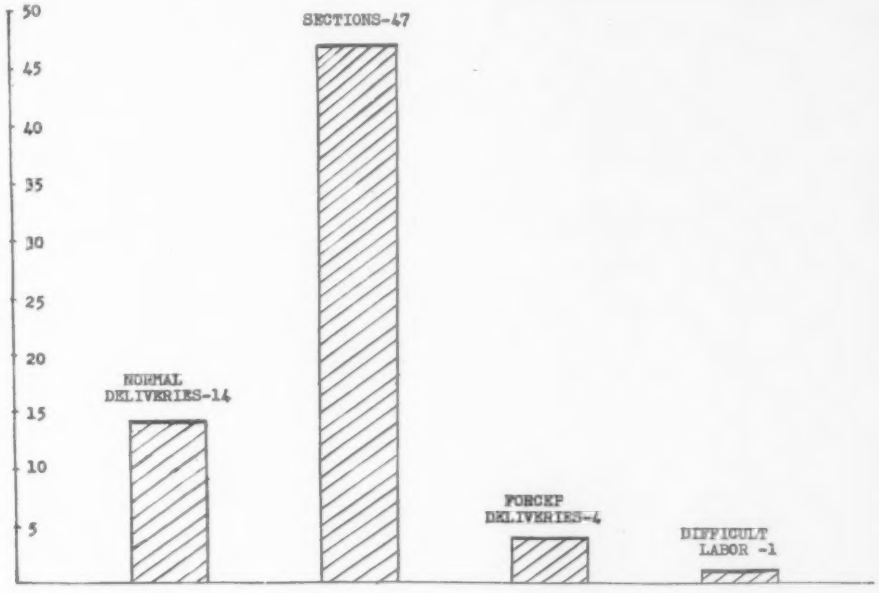

CHART I. Results in cases in which one or more diameters were contracted more than 10 mm.

anteroposterior diameters of the mid-plane and outlet only. This diameter is measured from the tip of the sacrum to the inferior symphysis pubis and serves as the anteroposterior diameter of both planes. In each one of the 7 cases the other diameters of the pelvis were normal or above the average and each of the 7 cases delivered normally. However, when the contraction of this diameter was complicated by the shortening of one or more of the other diameters, abnormal delivery resulted in the great majority of the cases. The final results of the pregnancies in this group are shown diagrammatically in Chart 1.

This study has emphasized the importance of the interspinous or transverse diameter of the mid-plane in pelvimetry (Chart 11). Of the 45 patients with contracplane of least pelvic diameters, and the outlet or inferior strait. The following diameters were measured:

Inlet:

Anteroposterior: Measured from the sacral promontory to the superior symphysis pubis.

Transverse: Measured across the greatest width of the pelvic brim at right angles to the true conjugate.

Right Oblique: Measured from the right sacroiliac articulation at the pelvic brim to the left iliopectineal eminence.

Left Oblique: Measured from the left sacroiliac articulation at the pelvic brim to the right iliopectineal eminence.

Mid-plane:

Anteroposterior: Measured from the tip of the sacrum to the inferior symphysis pubis.

Transverse: Measured between the ischial spines.

Posterior Sagittal: Measured from the tip of the sacrum to the center of the interspinous diameter.

Outlet:

Anteroposterior to the Sacrum: Measured from the tip of the sacrum to the inferior symphysis pubis.

Anteroposterior to the Coccyx: Measured from the tip of the coccyx to the inferior symphysis pubis.

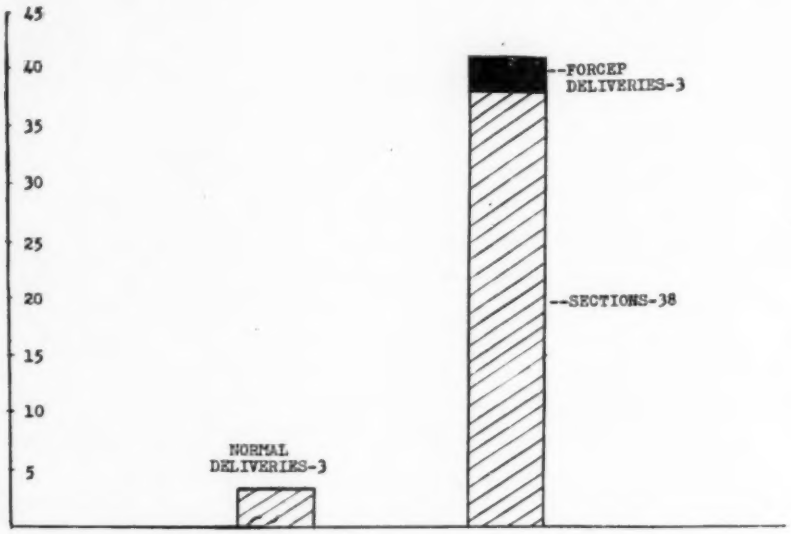

CHART II. Results in cases in which the interspinous diameters (mid-plane) were contracted more than 10 mm.

Transverse: Measured between the ischial tuberosities.

Posterior Sagittal: Measured from the tip of the sacrum to the mid-point of the transverse diameter.

Measurements of the posterior sagittal diameters of the mid-plane and outlet have been made routinely for a shorter period and we have not attempted to evaluate these diameters in this series of cases. However, in the cases followed we are in agreement with Johnson that when the sum of the posterior sagittal and the transverse diameters of the outlet is 17 cm. or more little or no difficulty should be expected from disproportion. We are unable at this time to make any mathematical statement regarding the relation of the posterior sagittal of the mid-plane to the interspinous diameter.

No attempt has been made in this study to obtain postpartum measurements of the fetal skull in each case. However, the diameters of the skull are routinely measured at the time roentgen pelvimetry is done, which is ordinarily about two weeks before the expected date of delivery. In less than 5 per cent of cases fetal movement has prevented accurate measurements of the fetal skull. This has been found especially true in breech presentations. It is believed that the factor of fetal movement would interfere with fetal skull measurements by any technique or method employed but that the evidence of such movement is better observed on films viewed stereoscopically. In a small series of cases in which head measurements were obtained after delivery, the accuracy of the method proved highly satisfactory.

One of the important advantages of stereoroentgenometry is the stereoscopic visualization of the relationship of the fetal skull to the bony pelvis. Very much valuable information can be obtained from

such a study as shown by Caldwell and Moloy.[1,2] The study and classification of the pelvic type correlated with the study of the diameters obtained by stereoroentgen pelvimetry offers information of the greatest value to the obstetrician.

SUMMARY AND CONCLUSIONS

1. In a series of 205 patients with normal diameters as determined by stereoroentgen pelvimetry, 203, or 99 per cent, delivered normally.

2. In a group of 61 patients in whom more than one pelvic diameter were contracted more than 10 mm., 52, or 85.2 per cent, had difficult or prolonged labors or required operative deliveries.

3. The Johnson method of stereoroentgenometry combined with the stereoscopic study of the relationship of the bony pelvis and the fetal skull are of considerable value in the prognosis of the future course of pregnancy.

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ROENTGENOLOGIC LOCALIZATION OF THE PLACENTA WITHOUT CONTRAST MEDIA*

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THE purpose of this presentation is to describe a roentgenologic method of determining the position of the placenta without administering or utilizing opaque media. I am led to believe that such knowledge of placental location is often of value to the obstetrician, and presume if the information can be secured without disturbance to the mother or fetus that such would be additionally desirable.

It has been the general understanding of roentgenologists and clinicians that the soft tissue of the uterus and of the secundines cannot be visualized by the ordinary methods of roentgen study. For this reason, various types of opaque medium and various methods of their introduction have been employed during the past twenty-five years. This work was first inaugurated by Carey, who, in 1914, published a short preliminary note on the determination of patency of the fallopian tubes by the use of collargol. This article was followed, in a short time, by a very complete report of roentgen diagnosis in gynecology with the aid of intrauterine collargol by Rubin, in 1915. Whether these two made the first attempt to demonstrate the contours of the uterus by opaque media is open to some conjecture, although their publications were certainly the first to appear in the literature. In 1912, Le Lorier made intrauterine injections of electrargol in order to determine the patency of the tubes, and presented his work at the Congress of Lille, in 1913, but did not publish it. Early work in this field was also done in Pozzi's Clinic by Dernier. Dernier used collargol and the patient developed peritonitis. After this untoward reaction the method was discontinued at Pozzi's advice.

Following these pioneer efforts in visualization of the uterus and tubes, there occurred a rapid development both in method and in media. First to employ lipiodol in this field was Carlos Heuser, of Buenos Aires. Heuser applied this method of study to the diagnosis of pregnancy, having the temerity to inject lipiodol solution through the cervix into the pregnant uterus. He affirmed that this method of study had provoked no disturbance of the pregnancy and that by means of it he was able to outline the peculiar contours of the implanted ovum. Those who undertook to follow his suggestions discovered, however, that the production of miscarriage was very common. Miller and Martinez reported 3 cases of abortion among 15 cases which were studied by the Heuser method. As a result of these cases, the injection of media through the cervical channel during pregnancy was abandoned.

The next step in the history of this field of roentgenology occurred when Menees, Miller and Holly reported a series of cases in which they had injected a radiopaque solution through the abdominal wall into the amniotic cavity, by means of which the outline of the fetus and the contour of the placenta were made visible; in fact, so effective was the contrast medium that in many instances they were able to determine the loops of cord around the neck, and the sex of the fetus. For purposes of their study some 10 to 15 cc. of a 1 to 1 solution of U.S.P. strontium iodine solution in water was used. They reported 21 cases with no injuries or toxic effects in the mother. In one instance a low implanted placenta was perforated and the patient started in labor. They suggested that the method would be of value in the diagnosis of placenta praevia. This method of examination was tried out by several other clinics with less favorable results than had been reported by the orig-

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inal workers. Burke employed the method in a series of cases and reported his results in 1935. He used uroselectan B instead of strontium iodide and secured very successful roentgenograms of the fetus and secundines. Burke felt that the method had value in the diagnosis of placenta praevia, but warned or its effect in inciting labor. He found that labor started in every instance, except one of hydramnios, within twenty-four to forty-eight hours after the injection was made, although he had no case of maternal or fetal injury in 75 cases.

Adair and Davis reported their results with skiodan for amniography in 1933, and their conclusions were that the results obtained scarcely justified the risks that were associated with the undertaking. Cornell and Case, in their report in 1934, considered that the method has a limited field and has actual dangers. In spite of their best effort to avoid the placental site in making the injection, they found that the needle had punctured the placenta in 6 cases. In a final discussion, Cornell stated that he would consider it wise to discontinue the intrauterine injection of opaque medium during pregnancy. So discouraging were these various results and reports that amniography with the use of opaque medium has been almost completely abandoned.

The contributions of Ude, Weum and Urner constitute the next chapter in the roentgenological diagnosis of placenta praevia. The preliminary report of these investigators was published in 1934. They recommended the introduction of opaque medium into the bladder, suggesting specifically the use of 40 cc. of a 12.5 per cent solution of sodium iodide as a contrast medium. Anteroposterior and lateral roentgenograms were taken and the relationship of the fetal presenting head of the bladder was carefully noted. Unusual separation of the head from the bladder or unusual deformity of the bladder was taken to indicate the presence of intervening soft tissue which was presumed to be placenta. In the majority of cases in which these characteristic findings were noted the diagnosis was confirmed either by the clinical course of vaginal delivery and the condition of the placenta or by the findings upon cesarean section.

Further cases were reported by Ude and Urner in 1935 and the authors state, upon the basis of their ample experience that "We have found that the presenting head invariably lies directly against the lower anterior wall of the uterus unless it is displaced upward by a solid mass, either by the placenta, blood clots from a premature separation of the placenta, or from some abnormality of the fetus or pelvis." The work of Ude and Urner has received wide and favorable comment and a number of publications have confirmed the accuracy and usefulness of the method (Priest, McIver, Friedman and Macdonald, Wells, McDowell, Hall, Currin and Lynch and others).

The method, however, does not provide for the diagnosis of position of the placenta when there are abnormal presentations such as the breech, the shoulder, etc., nor does it provide for a differential diagnosis of high displacement of the head in a contracted pelvis. These shortcomings are acknowledged freely by the original authors. In addition, several observers have noted cases where the presenting part has been displaced above the bladder and no evidence of placenta praevia was found. Such observations are reported by Hundley *et al.* in a contribution on the physiological changes occurring in the urinary tract during pregnancy. In studying the urinary tract, after intravenous pyelography, they found in 10 of 27 patients a space between the shadow of the fetal head and the outline of the bladder which varied from 1 to 2.5 cm. in thickness. In none of these 10 cases was placenta praevia found to be present.

In very recent years an endeavor has been made to bring out the contour of the placenta by the injection of thorotrast. This material, administered intravenously, is taken up by the lymphatics of those organs which are rich in reticulo-endo-

thelial structure. For this reason it finds its way rapidly into the placenta and there casts a very decided shadow upon the roentgenogram. Thus far the method has not been acceptable for use in the human being, and has been limited to animal experimentation, for it has been found that the presence of the opaque medium in the placental structure interferes with the vitality and intrauterine life of the fetus, and in most experimental animals the fetus has eventually died in utero.

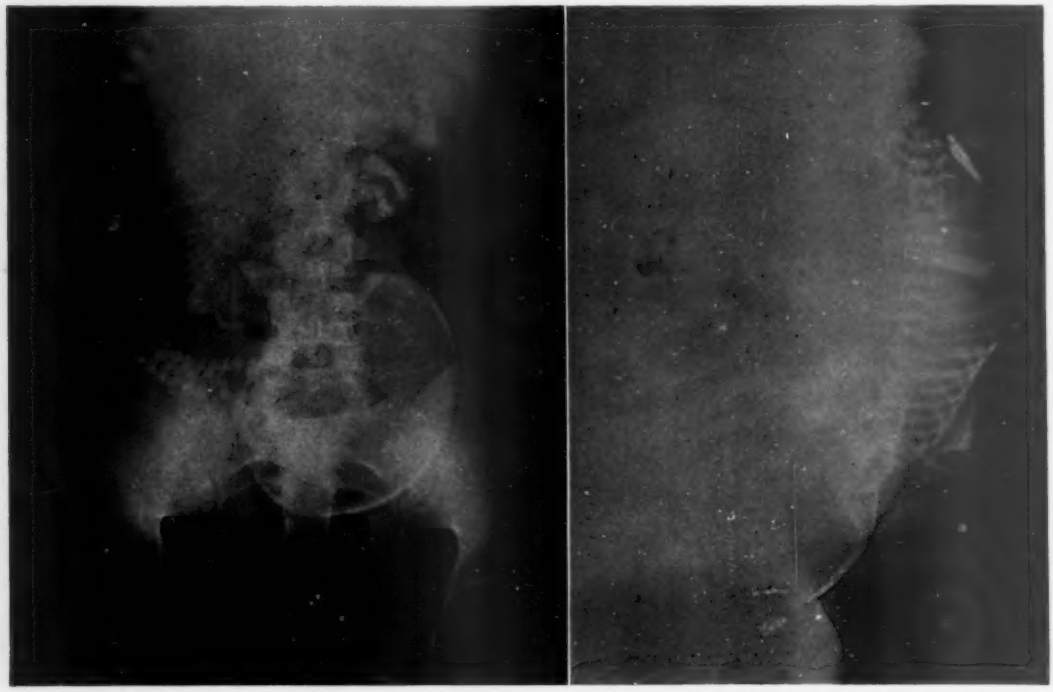

FIG. 1. Placenta praevia. Note absence of placental shadow in lateral view, and upward displacement of fetal head in anteroposterior view.

My interest in the problem of placental localization dates from the period of amniography and started with studies which the Obstetrical Department of the Jefferson Hospital and the Roentgenological Department undertook in 1931 to confirm the observations of Menees *et al.* The injections were made in the Obstetrical Department and roentgenograms were taken in our department. We were able to achieve excellent visualization of the fetus and of the placenta and, from the standpoint of roentgenology alone, the method was an entire success. Obstetrically, however, the method proved exceedingly dangerous. In one instance in which sodium iodide was used through error, the fetus immediately succumbed. In several instances the surface of the fetal body was traumatized by the injection needle and in the majority of cases labor started within twenty-four to thirty-six hours after the injection of the opaque material. In 2 instances the placenta was perforated and the fetus stillborn. Naturally, this method was promptly and permanently abandoned.

While examining these roentgenograms, having before me so clearly the placental area, I began comparing with them some of the roentgenograms of pregnant women which had been taken without contrast medium, and much to my surprise I found that certain zones of the uterine body which I had taken to be amniotic fluid corresponded to the placental site and presented certain features which upon further

study served to distinguish them as distinctly soft tissue rather than fluid. I then began taking roentgenograms of the fundus of the pregnant uterus with soft tissue technique for the specific purpose of bringing out these details, and found that in practically every instance in which the placenta was located in the body or the fundus of the uterus it could be visualized either in the anteroposterior or the lateral roentgenogram. After some experience and trial of the method I felt sufficiently confident of the findings to make report of the position of this organ in each of the roentgenograms which we made of the pregnant uterus. This phase of the study was started in 1932 and was developed during the subsequent six months. By the latter part of 1933 I began making formal reports of the placental location in addition to the routine description of the size and contour of the pelvis, position of the fetus, proportions between the fetus and maternal pelvis, etc. During the past six years the Department of Roentgenology has submitted to the obstetricians over one thousand reports of placental localization. Judging from the comments of the Obstetrical Department, these reports have been of service in the handling of those complications of pregnancy and labor which have to do with position and attachment of the placenta.

Fig. 2. Left occipitoposterior position of the fetus. Note that the placental shadow is anterior in the lateral view.

My experience with this roentgenologic method leads me to believe that not only is it accurate, but has certain advantages: (1) it ordinarily requires no special preparation of the patient; (2) it makes unnecessary the injection of opaque medium, either into the amniotic cavity or into the bladder; (3) it permits of a determination of the position of the placenta not only in head presentation but also in those abnormal presentations which seem so frequently associated with placenta praevia, that is the breech, the shoulder, the face, the brow, etc., and (4) it permits of the making of a diagnosis without any local manipulation of the pelvis without the possibility of disturbing the

placental site, or introducing infection.

The diagnosis from the roentgenogram is dependent upon the recognition of the placental shadow, either in the anteroposterior or lateral roentgenograms, or in some instances in both. This shadow is usually on the ventral side of the fetus and is in continuity with the wall of the uterus. It is not changed by shifting the patient from one side to the other or by the assumption of the erect posture and is definitely not cast by the amniotic fluid. In placenta praevia the extent of shadow which is found in the body of the uterus depends upon the type and degree of placenta praevia. In lateral placenta praevia the shadow is located in the lower portion of the uterine body and disappears behind the shadow of the pelvic girdle. In complete placenta praevia the placental shadow is absent from the upper uterine segment. While it is not usually visible in the lower segment either, because of the concealment by the pelvic bones, yet the high displacement of the presenting part speaks for its presence there. The diagnosis of complete placenta praevia by this method, therefore, is dependent upon the absence of placental shadow from the upper segment of the uterus and displacement of the presenting part from its normal position.

The technique employed in the roentgen studies is as follows:

1. Ordinarily no laxative or purge is given nor even an enema, inasmuch as these measures may create disturbance of the placental attachment. If the roentgenograms taken under these circumstances are not entirely satisfactory, the lower bowel may be emptied by gentle enema, for an accumulation of feces in the rectum and sigmoid may of itself displace the presenting part.

2. Two of the roentgenograms are taken using the technique for bone detail, the first in an anteroposterior position with the patient lying prone on the table and the tube centered midway between the pubis and the umbilicus; the second, in the lateral position with the tube centered over the trochanter of the femur. Then a lateral roentgenogram is made with soft tissue technique, with the tube centered at the lumbar region to reveal the contour of the body and fundus of the uterus. Inspection of these three roentgenograms usually affords sufficient information to make an accurate diagnosis of the position of the placenta, although if special conditions require, additional roentgenograms with soft tissue technique may be taken at other angles. The report that is made from these studies ordinarily includes a decription of the features of pelvic architecture, the relationship of the fetal parts to the pelvis, and the position of the placenta.

At the time I undertook these studies in 1932 I could find in the literature no reference to roentgenological visualization of the placenta without the use of an opaque medium, but upon reviewing the literature of the last few years, I find that there are several investigators who have recorded a similar observation in an occasional case or a limited series. Ude and Urner describe one case in which the shadow of placenta praevia was observed in a roentgenogram without contrast medium, and in 1934 Snow and Powell published a résumé of their observations upon roentgenological visualization of the placenta. They state: "We have been able to demonstrate the placenta in the routine roentgen examination of the abdomen of pregnant women in a very high percentage of cases. In fact, we believe that with a reasonable amount of technical accuracy in making the exposures, no difficulty will be encountered. The placenta was not seen heretofore because we did not look for it." These observers presented a report of some 75 cases in which observations were made, but state that they did not have the opportunity of studying placenta praevia. It is probable that their investigations were going on about the same time as mine and with their viewpoint I am entirely in accord.

SUMMARY

I trust that the facts we have presented here will serve to emphasize the value of this method of study of placental position.

In summary, let me state that the diagnosis of placental position has been made in over one thousand cases by roentgen examination without the use of contrast medium; that the findings in the instance of placenta praevia have been confirmed by the obstetrician, both in vaginal delivery and cesarean section; that the method has received acceptance in the obstetric clinic and apparently has come to play an important part in the management of certain obstetric difficulties where such knowledge is of importance; that the results have been achieved without disturbance of the patient or without the necessity of the injection of any contrast medium which might endanger the pregnancy or cause inconvenience to the patient, and that while the method requires a certain amount of study, observation, and special interest on the part of the roentgenologist, yet it is in no way beyond the ability of the specialist in this field.

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SYPHILITIC SPONDYLITIS*

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INTRODUCTION

MUCH has been written about syphilis of the bony skeleton and about Charcot's disease of the spine and other bones and joints, but references to syphilis of the spinal column have been few. This meager literature is partly due to the fact that the diagnosis is difficult to prove, even on histologic examination.

Syphilis of the vertebrae should not be confused with Charcot's spine. Charcot's spine is secondary to changes in the dorsal root ganglia and dorsal columns of the spinal cord associated with loss of sensory perception. This loss in turn impairs the reparative mechanisms of the spine to the traumatic effects of everyday life. Minute fractures occur which are not observable roentgenologically. Hemorrhage ensues with subsequent disintegration of the constantly traumatized bone, with a loosening of the ligamentous structure which is followed by extensive areas of new bone formation. The end-result is a combination of bizarre bone destructive and extensive new bone productive changes.

Syphilitic spondylitis, on the other hand, is elicited by an invasion of the periosteum and bone by *Treponema pallidum*.

HISTORICAL REVIEW

The earliest case report of syphilitic spondylitis was by Monroe[8] in 1772, who published it under the title of "venereal eroding ulcer and venereal caries of the vertebrae of the neck."

Frank,[3] in 1798, reported a case of syphilitic areas involving the third, fourth and fifth lumbar vertebrae.

In 1904, Neumann[10] collected 55 cases of which 36 involved the cervical spine, 6 the dorsal and 7 the lumbosacral spine.

In 1911, Ziesche[19] wrote a comprehensive review on the subject. He compiled 88 cases, 86 of which were from the literature. He found that men were more commonly affected than women, the ratio being 71.4 per cent to 28.6 per cent. The disease was fairly evenly distributed among the various age groups. The regional incidence showed approximately 70 per cent in the cervical region, 13.5 per cent in the dorsal column, and the rest in the lumbar or sacral column, or multiple distribution.

The great majority of the cases of Neumann,[10] Petren[12] and Ziesche[19] were not confirmed by autopsy, the diagnoses having been based mostly on clinical, and, in a few instances, on roentgen findings.

In 1914, Hunt[6] added 4 cases. Three of these showed roentgenologic evidence of the disease, but in the fourth instance no roentgenographic changes were seen and the diagnosis was based on clinical arthritis in a known syphilitic patient which responded to specific therapy. He stated that up to that date the number of reported cases of syphilitic spondylitis was 100.

In 1915, Whitney and Baldwin[17] reviewed the roentgenograms of the spines of 100 consecutive patients with positive blood Wassermann reactions. They diagnosed gummatous lesions of the spine in 3 patients, based on the finding of destructive changes in the vertebrae. They stated that 68 of these patients had clinical symptoms referable to the spine such as localized stiffness and hypotonicity without positive roentgen findings. They concluded that syphilitic spondylitis is more common than suspected, and they stated that all patients who have a positive Wassermann reaction associated with hypotonicity and localized stiffness of the vertebrae should be suspected of having syphilitic spondylitis.

In 1925, Cofield and Little[2] reported upon 111 cases listed as luetic bone and joint disease in the files of Cincinnati General

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Hospital over a period of eight years. Nine of these presented roentgen signs interpreted as syphilitic spondylitis. One of these cases was cited as having been examined at autopsy, showing ankylosis of the cervical vertebrae. The rest of them were not proved.

In 1929, Woringer[18] published a monograph on syphilitic Pott's disease. He recognized three forms of the condition: (1) the osteochondritic, (2) the periosteal, and (3) the gummatous type.

According to him, the osteochondritic form occurs primarily in the fetal period and the first two months of life.

The periosteal form begins in the third month of life and persists thereafter. These intrauterine and lesions of early infancy are usually generalized and symmetrical.

The gummatous type produces foci of bone destruction with frequent involvement of the intervertebral disc simulating the appearance of tuberculous spondylitis, hence his term "syphilitic Pott's disease." This lesion is more localized, circumscribed to one of several bones, and occurs in later life.

In 1931, Abernethy,[1] in 1932, Horn,[5] and in 1933, Gill and Frazer[4] each reported a clinical case of syphilitic spondylitis which was diagnosed by roentgenographic changes of the vertebrae and positive Wassermann reaction, all of which responded both roentgenographically and clinically to antiluetic therapy.

The most recently reported autopsied case was that of Péhu and Boucomont[11] in 1933. Their patient, a child aged fifteen months, had involvement of the long bones and the vertebral column. The twelfth thoracic and the first and second lumbar vertebrae presented a moth-eaten appearance, the disc between them being narrowed. There was a gibbus but no paravertebral abscess and complete microscopic studies showed findings which were consistent with the diagnosis of syphilitic spondylitis but not pathognomonic of it.

In 1938, Sprung[15] reviewed the problem of luetic spondylitis and reported a case with clinical and roentgenologic findings but no other proof.

In 1941, Sgalitzer[14] reported 3 patients suffering from syphilitic spondylitis of the cervical column proved by roentgenologic evidence and response to antiluetic therapy.

The above review demonstrates the great scarcity of pathologically verified cases of syphilitic spondylitis.

PATHOLOGY AND PATHOGENESIS

Ziesche believes that the pathologic anatomy of syphilitic spondylitis is the same as for other bones. The disease starts in the periosteum as a periostitis with a deposition of embryonal cells between the periosteum and overlying connective tissue. An inflammatory edema of the connective tissue ensues. In this stage, the disease may heal. If it persists, the embryonal cells become osteoblasts and periosteal new bone production occurs. Osteophytes or exostoses may form. The inflammatory process extends to the underlying bone and new lamellae form which become deposited on the haversian canals. This leads to a condensation of the involved bone, even to the point of eburnation.

The inflammatory process may continue to progress and the haversian canal may become eroded from its inner surface, leading to bone softening. This he calls "osteitis rarificans." It heals with the aid of hyperplasia of the bone.

A still more marked inflammatory osteoperiostitis and osteomyelitis shows a tendency to a different type of productive process, which results in formation of gumma. Eburnation, however, may occur here also.

Bone necrosis may also occur as the result of occlusion of the blood vessels within the thickened walls of the haversian canals. The necrotic bone may sequestrate.

There is little tendency to pus formation, and abscesses are distinctly uncommon although they may occur.

According to Woringer, the ligamentous structure as well as the dura may likewise be infiltrated by gumma. The adjacent

nerves may be involved primarily by the specific inflammation, or secondarily by pressure from the tumefaction.

The discs may be involved by the gummatous process and destroyed by syphilitic granulation tissue. A secondary superimposed infection may likewise be present.

ETIOLOGY

The organism is, of course, the *Treponema pallidum*. As previously indicated, there is a marked predilection for involvement of the cervical vertebrae. The reason for this is not known. In syphilitic osteitis elsewhere it seems that the bones most affected are those exposed to slight trauma and pressure, such as the frontal bone, the sternum, clavicle, radius and tibia. The cervical vertebral column is the most freely movable part of the spine and this may play a part in its relatively greater frequency of involvement.

Secondary invaders and infection may participate in this phenomenon. Hunt believes this is due to an extension from a pharyngeal ulceration, and this is Neumann's contention. Ziesche's patient had an ulcerative area in the pharynx with a fistulous tract extending to the vertebrae, and sequestration. Moreover, congenital syphilitics in whom gummatous involvement of the pharynx is rare do not show the same proportional involvement of the cervical column.

In most of the cases, spondylitis occurs in the malignant form of syphilis where, despite repeated therapy, new phenomena present themselves. The condition may occur in congenital syphilis, or during the second or third stages of acquired syphilis. The disease rarely develops before the secondary skin changes set in. However, Ziesche reports a case of a two year old infant who was infected by his nursemaid and who developed syphilitic spondylitis before the lingual mucous plaques or the plantar pemphigus appeared.

As in other syphilitic osseous lesions, the absence of a history of a primary or secondary syphilis has little importance. Stokes[16] reviewed 239 patients with late luetic osseous and joint lesions and found that 64 per cent gave no history of a primary lesion and 87 per cent denied a secondary eruption. The blood Wassermann reaction was negative in 17 per cent of the cases.

CLINICAL SYMPTOMATOLOGY

The symptomatology is not definite. There is localized pain which may be more marked at night, stiffness, and tenderness to palpation as the result of the periostitis. The normal lordosis of the spinal column is straightened out. The head is held stiff and motions are avoided. According to Hunt, neurological symptoms occur in about 26 per cent of the cases. Compression of the cord is seldom marked enough to produce a compression myelitis. Sequestra may be coughed up in the cervical type of involvement. Coexisting lesions in other bones are common, especially the sternum, clavicle, tibia and radius.

Occasionally sudden death has been described, especially when erosion into an artery has occurred. Dominel, quoted by Ziesche, describes a case in which erosion into a vertebral artery occurred with bleeding into the spinal subarachnoid space. Landrieux, quoted by Ziesche, described a case in which autopsy revealed a fistulous tract into the internal carotid artery.

We have observed 3 patients suffering from syphilitic spondylitis. All of these patients showed involvement of other bones in addition to the vertebrae. Autopsy was performed on 1 of the cases and the diagnosis was substantiated by histologic findings. In the other 2 patients, all the criteria of a clinical syphilitic spondylitis were present (positive Wassermann reaction and response of some of the bone lesions to antisyphilitic therapy).

CASE 1. F. S., aged sixty-three, colored male, was admitted to the hospital on September 1, 1937, with a chief complaint of pain and limitation of motion in the right elbow of three weeks' duration. He had had a painful neck of

five months' duration with limitation of motion. He had also noticed a swelling in his right supraclavicular fossa for the past five months. He had lost 42 pounds in weight during that time. His first wife had had 2 stillbirths, but otherwise the past history revealed nothing of significance.

On physical examination, his temperature was 38.5° C., pulse 114, respiration 20 and blood pressure 140/88. It appeared as though he had been ill for some time. Both pupils reacted to light and on accommodation and examination of the eyegrounds showed a moderate venous nicking. There was generalized moderate enlargement of all the lymph nodes, most marked in the right supraclavicular fossa. At the costochondral junction on the left side of the tenth rib there was a hard immovable lump which was smooth and non-tender. The reflexes were normal.

The blood Wassermann reaction was four plus and an examination of the spinal fluid showed no cells, a negative Pandy test, a low first zone gum mastic curve, and normal chlorides and sugar. A culture of the abscess of the left sixth rib revealed no growth after five days. A biopsy of a lymph node and of the involved rib was reported as infectious granuloma, probably tuberculosis. The patient continued to run a low grade fever, always fluctuating around 38.0° C., but otherwise was in good physical condition. However, two weeks after admission he collapsed with all the signs and symptoms of a hemiplegia involving the left arm and left leg. His pulse became imperceptible, his respirations slow, and his blood pressure dropped so that no readings could be obtained. Death ensued.

Fig. 1. Case 1. Lateral view of the cervical spine shows syphilitic spondylitis.

Fig 2. Case 1. Anteroposterior (*A*) and lateral (*B*) roentgenograms of the cervical spine specimen.

The various roentgen examinations which were obtained were as follows:

A posteroanterior view of the chest showed a dilatation of the aorta indicating the presence of a fusiform aneurysm.

Roentgenograms of the entire length of the right humerus showed periosteal thickening in multiple layers extending upward to about the midportion of the bone.

There was evidence of a slight amount of bone destruction throughout the tenth left rib near the costochondral junction involving an area about 2 cm. in length.

There was an extensive involvement of the third, fourth, fifth, sixth and seventh cervical vertebral bodies with marked irregularity of the contours, narrowing of the intervertebral spaces and overbridging spurs along the borders of the vertebral bodies (Fig. 1 and 2). The third, fourth and fifth lumbar vertebral bodies were also irregular in contour and surrounded by hypertrophic spurs.

These multiple bony lesions were interpreted as being due to a low grade chronic infectious process. In view of the clinical history, these changes were suggestive of syphilitic bone lesions.

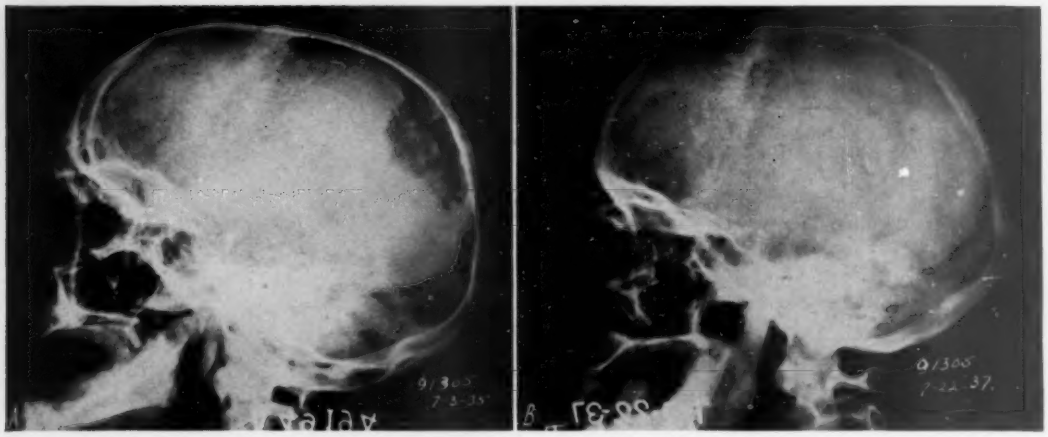

FIG. 3. CASE II. Roentgenograms of the skull before (*A*) and after (*B*) specific antiluetic therapy, showing the healing of the gummatous lesion of the parietal region in two years.

At autopsy, the findings were gummas of the liver, gumma of perigastric lymph node, chronic periostitis and osteomyelitis of the sternum, left tenth rib, cervical spine and right humerus, probably syphilitic, syphilitic aortitis, passive hyperemia and edema of the lungs, and other findings which were incidental. Almost complete stenosis of the cerebral vessels was also found. Dr. Howard T. Karsner believed that although no pathologist could make a positive diagnosis of infectious granulomata on the bone lesions, in the light of the clinical findings, the presence of syphilitic aortitis, and of the gummas of the liver, it was justifiable to attribute all of the changes to syphilis.

FIG. 4. CASE II. Roentgenogram of the lumbar spine obtained at the time the gumma of the skull was first noted. No other roentgenograms of the spine were requested at this time.

Section through the vertebral bodies of the cervical spine shows destruction of the intervertebral discs and gross irregularities of the bone architecture. The cancellous part is dark gray and friable in nature in contradistinction to the normal red bone marow in the normal areas. There is no involvement of this portion of the spinal cord.

Decalcified sections through the cervical vertebrae and the distal end of the right humerus show considerable fibrous proliferation of the periosteum which tissue is old and well formed. There are numerous areas of granulation tissue in the bones and periosteum extending out for a short distance in the soft tissue with marked lymphocytic infiltration of dense granulation tissue. In many areas the bone is replaced by this tissue.

CASE II. H. B., male, negro, aged fifty-three, was admitted June 22, 1935, from the Out Patient Department complaining of lumps on the head of two months' duration. For four months he had had severe headaches which had been becoming increasingly worse. He had had a penile lesion and urethral discharge in 1902. He had been hospitalized in Toledo in 1934 where he was given thirteen arm and hip injections for the treatment of "blind staggers."

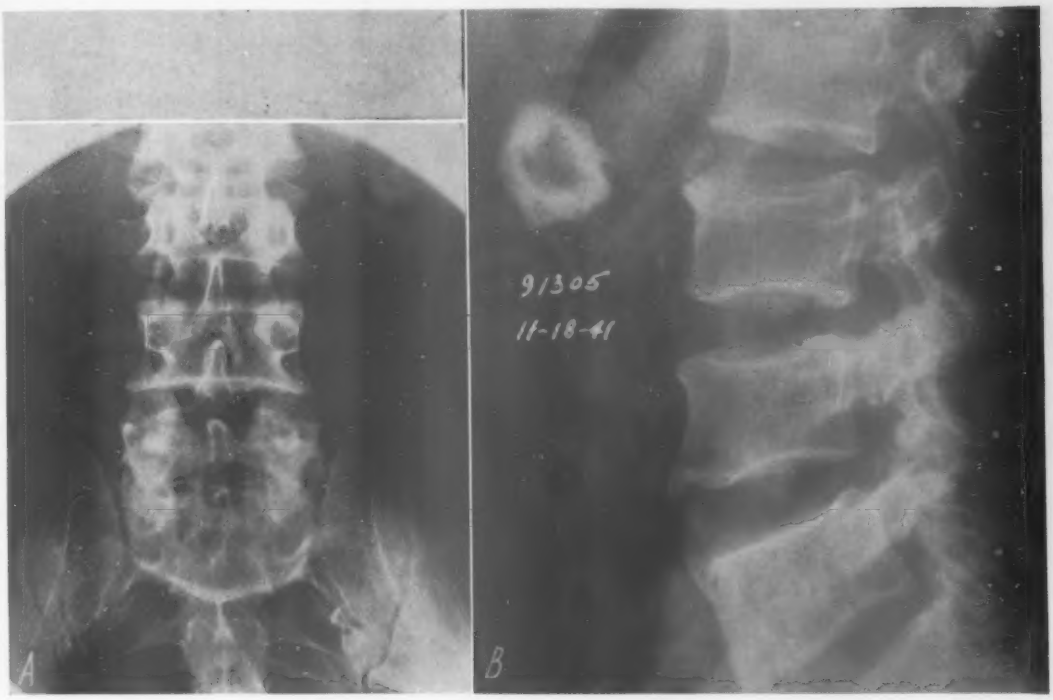

Fig. 5. Case 11. Anteroposterior (*A*) and lateral (*B*) roentgenograms of the spine six years after intermittent antiluetic therapy.

He had been a heavy drinker of alcohol until 1917. Upon physical examination, he was well developed and nourished and not very ill. On the left side of the vertex of his skull there were two small firm masses which were smooth, slightly tender and appeared to be in or part of the bone. There was a diastolic murmur in the aortic area and his blood pressure was 190/80. His blood Wassermann reaction and Kline precipitation tests were four plus. One cubic centimeter of his spinal fluid also had a strong positive Wassermann reaction, with a low first zone gum mastic curve.

The roentgen examinations at the time included the following:

A roentgenogram of the chest showed the heart shadow to be enlarged and the aorta to be diffusely widened. In the cartilaginous end of the first right rib, and in the sixth rib on the left, there were punched-out areas of bone destruction.

Roentgenograms of the skull showed a large moth-eaten area of irregular but generally diminished density in the left parietal bone, measuring 6 by 3.5 cm. The bone changes, mainly those of the skull, suggested a syphilitic osteitis (Fig. 3, *A* and *B*).

Antiluetic therapy consisting of potassium iodide and bismuth was begun on the fourth day and by the twelfth day there was a slight reduction in the size and tenderness of the nodules of the skull. By the twenty-first day he was practically asymptomatic.

Roentgenograms of the skull taken again on July 22, 1937, show that the gumma of the right parietal bone had completely healed, but the lesion in the first rib was increasing in size.

Roentgenograms of the lumbar vertebrae were obtained in 1935 (Fig. 4) and showed no evidence of a pathologic process. No further studies of the spine were obtained until November 18, 1941, and these were at the request of the Department of Roentgenology because of its interest in luetic lesions of the spine. The lateral view of the lumbar vertebrae showed a mottled decrease in density throughout the anterior portion of the fifth lumbar. The posterior portion of the fifth lumbar was sclerotic. There were large bony bridges between the fifth lumbar and first sacral and large spurs between the fourth and fifth lumbar (Fig. 5, *A* and *B*). At this time it was noted that the body of the third cervical was irregular in outline with a rearrangement of the trabeculae of the peripheral portions of the body (Fig. 6). In view of the patient's clinical history of mul-

FIG. 6. Case II. Roentgenogram of the cervical spine taken six years after intermittent antiluetic therapy showing involvement of the third cervical vertebra.

CASE III. J. J., male, negro, aged forty-seven, was first seen in the Out Patient Department on October 8, 1934, with a chief complaint of painful neck of one year's duration and stiffness of the neck of six months' duration. He had also had moderate pain in the right knee and right hip for the past year. He denied any venereal contacts and his general health was very good. Upon physical examination it was noted that he could not flex his head and could turn it only slightly. His back was very stiff and he could bend forward only in the lower lumbar region. Lateral flexion was also limited. There were no other significant findings and his reflexes were completely physiological. His pupils reacted to light and on accommodation. A clinical impression of atrophic arthritis of the spine was made and when there was no response to salicylates and physiotherapy, roentgenograms of the cervical spine were made. These showed all the vertebral bodies of the cervical spine to be deformed. The bone trabeculae throughout them were markedly rearranged. There were small areas of diminished density interspersed

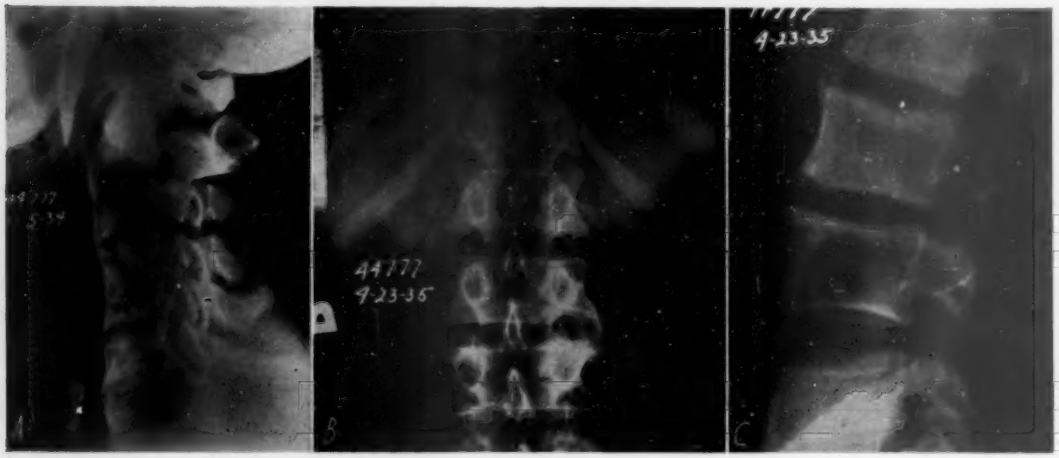

FIG. 7. Case III. Roentgenograms of the cervical (*A*) and lumbar (*B* and *C*) spine before any specific antiluetic therapy.

tiple gummas throughout many portions of the bony skeleton, it was believed that these most likely represented syphilitic osteitis of the vertebrae. They were asymptomatic and were overlooked during their active phase.*

throughout the vertebral bodies and extensive bone destruction in the anterior half of the axis and atlas. The body of the fifth cervical vertebra was markedly collapsed. The anterior portions of the vertebral bodies were overbridged by spurs and ankylosed. Many of the intervertebral discs were narrowed (Fig. 7, *A*, *B* and *C*). The changes were interpreted as indicating a chronic osteomyelitic process, the etiology of which was uncertain. Syphilis,

* Autopsy was performed on February 24, 1943, after this communication was submitted for publication. Histologic examination of the involved ribs and vertebrae "showed dense fibrosis of periosteum and adjacent bone. These changes are not diagnostic of syphilitic involvement, but are entirely consistent with the diagnosis."

tuberculosis, and a nonspecific origin were suggested as possibilities.

A four plus blood Wassermann reaction was subsequently obtained. A course of antiluetic therapy was then instituted, with symptomatic relief. Roentgenograms of the cervical and lumbar vertebrae taken two years later showed an increase in the sclerosis of the involved vertebrae and some reconstruction of the destroyed vertebral bodies. It was concluded that these were most likely syphilitic in etiology, although the most that could be said objectively was that the findings were those of an ankylosing spondylitis (Fig. 8, *A*, *B* and *C*).

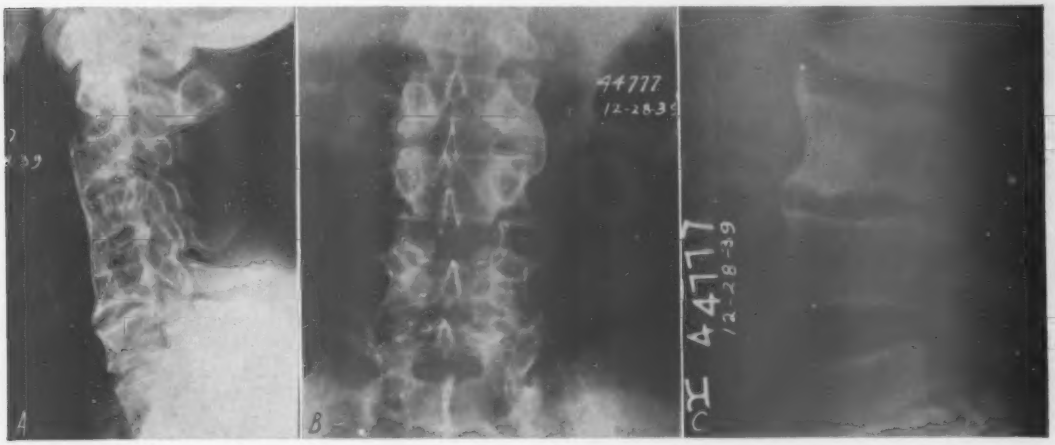

Fig. 8. Case III. Roentgenograms of the cervical (*A*) and lumbar (*B* and *C*) spine after specific antiluetic therapy.

ROENTGEN APPEARANCE

From the various reported proved cases, and from our own, we may conclude that there are certain common characteristics in the roentgen appearance in a certain group of cases which allow the roentgenologist to suggest the presence of a syphilitic spondylitis. Any part of the spinal column may be involved, but there is a predilection for the cervical spine and this is the location where, from the literature and from our own cases, we have found a certain similarity in the appearance of most of the lesions. There is usually evidence of destruction of the vertebral body, especially on its ventral aspect, but there is a marked tendency to osteosclerosis and hyperostosis even to the point of eburnation. There is usually calcification in the anterior and lateral ligaments leading eventually to complete ankylosis. The tendency to eburnation predominates over the tendency to destruction. The intervertebral space may be narrowed or of normal width. This change is in contradistinction to the statement by Sgalitzer who claimed that the intervertebral discs were always well preserved.

The vertebral body may appear somewhat rounded and even larger in size than normal, and the normal bony structure is replaced by either sclerosis or by areas of destruction. Occasionally the two forms are combined. The vertebral end plates may be moth-eaten in appearance or smooth. While in the cervical region the ligaments ossify in a rather uniform and smooth fashion, in the lumbar or dorsal vertebrae large pointed spurs may develop along the anterolateral borders of the end plates. When these changes are present the appearance may simulate a degenerative arthritic process. But while deforming spondylosis is usually a generalized condition involving all or large sections of the vertebrae, the spur formation in syphilitic spondylitis will usually be localized to only two or three vertebrae.

There is usually no paravertebral abscess shadow present although in rare instances it may occur (Horn's case). Sequestration may occur in the cervical column. Subluxation and compression of the vertebral body may occur, especially in the neck.

May, Decourt and Willm reported a case in which syphilitic spondylitis simulated the appearance of hemangioma. The fourth lumbar vertebra had a mottled appearance and its right side was cuneiform in shape. A check examination one year following antisyphilitic therapy showed the vertebrae to be recalcified.

Several reports mention a type of syphilitic arthralgia of the spine (spondylitis syphilitica simplex) characterized by severe pain in the spinal column due to swelling of the small intervertebral articulations. These produce no changes in the roentgenogram. The pain responds slowly to antisyphilitic therapy.

According to the case reported by Woringer, the eburnation or sclerosis may clear up with specific antiluetic therapy. Likewise, Sarrouy and Portier state that the destroyed areas may recalcify with specific therapy.

DIAGNOSIS

The diagnosis is not easy, but will probably be made more frequently if considered in the differential diagnosis of spinal column lesions. To substantiate the diagnosis, the following factors are necessary, which will depend upon a careful history, physical examination, serology, roentgen studies and other laboratory tests.

(1) Existence of active syphilis, either by congenital or determined by marital history, past history or clinical or serological manifestations.

(2) Appearance at an age when tuberculosis of the spine is rare and the absence of tuberculosis elsewhere, although the two diseases may be present simultaneously.

(3) Rapid improvement upon institution of antisyphilitic therapy, although according to Gill and Frazer a round cell sarcoma may also respond to antisyphilitic therapy and it is conceivable that iodides might benefit an actinomycosis also.

(4) The roentgen appearance, although certainly not universally identical, may be strongly suggestive.

(5) The disease has a predilection for the cervical region, although it may occur anywhere in the spinal column.

DIFFERENTIAL DIAGNOSIS

Differential diagnosis must include tuberculosis, nonspecific osteomyelitis, lymphoblastoma, localized metastatic tumor, or primary sarcoma of the spine. The nonspecific osteomyelitides must include those of staphylococcic, streptococcic, typhoid or melitensis origin. Tuberculosis may be differentiated by the fact that it usually begins in the region of the vertebral end plate and the intervertebral disc and leads to early decalcification and partial destruction of the involved vertebra. In the early stages it is a rather rapidly progressive disease. Increased new bone production may occur, but only in the later stages. Paravertebral abscess is usually present in contradistinction to syphilitic spondylitis.

Osteomyelitis from any cause is characterized by an acute onset accompanied by a great deal of pain and systemic reaction. The condition rapidly leads to bone destruction which is soon accompanied by more or less extensive areas of new bone production and rapid regeneration.

Typhoid spondylitis in its early stages is a rapidly advancing disease, but in six to eight weeks after onset it begins to produce spurs surrounding the bone destruction between two adjacent vertebral end plates. These spurs eventually become smooth and overbridge the two vertebrae in a characteristic fashion.

Lymphoblastoma and leukemia produce either bone destructive or new bone productive changes, or a combination of the two, but no spur formations around the vertebral bodies. These conditions are associated with other manifestations else-

where, helping to establish the diagnosis.

Primary sarcoma may be very difficult to differentiate from syphilitic spondylitis. However, coexisting involvement of other bones is rare and the condition usually shows a rapid progression in contradistinction to syphilis.

CONCLUSIONS

Three instances of syphilitic spondylitis are reported. One was verified at autopsy and two by their clinical course.*

The cervical spine is the most commonly involved part of the vertebral column where the lesion usually produces an extensive involvement of the column consisting of a combination of new bone productive and destructive changes associated with spur formations around the vertebral bodies and occasionally calcification of a large portion of the anterior ligament. The intervertebral disc may be intact or narrowed and some of the vertebral bodies may show collapse (Cases I and III).

Occasionally, however, only one cervical vertebral body is involved, as in Case II, where the appearance may cause great diagnostic difficulties unless lesions in other bones also suggestive of syphilis are present.

The involvement throughout the dorsal and lumbar vertebral column yields a less suggestive roentgenological appearance than the diffuse type of cervical involvement.

The disease may be present in only one vertebra or in two or three adjacent vertebrae. These vertebrae may show bone destructive or new bone productive changes, or a combination of the two. Occasionally it may lead to eburnation of the vertebral body. In the majority of instances, the vertebrae become surrounded by more or less marked spur formation imitating the appearance of a nonspecific inflammatory spondylitis.

The diagnosis of cervical syphilitic spondylitis causes no great difficulties, once the physician is conscious of this possibility. The localized cervical, dorsal or lumbar syphilitic spondylitis is more difficult of diagnosis. The etiology can finally be established only by careful clinical studies and by roentgenologic investigation of the entire skeleton which usually shows additional bone involvement.

* See footnote page 762.

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ANGIOCARDIOGRAPHY IN CONGENITAL HEART DISEASE

II. INTRACARDIAC SHUNTS*

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THE presence of defects in the cardiac septa as a result of developmental anomalies may result in the mixture of venous and arterial blood currents. The roentgenographic demonstration of these shunts and a more precise definition of associated changes has been made possible by the method of angiocardiography. In 1938 Castellanos, Pereiras and Argelio Garcia[3] successfully demonstrated in several infants a shunt between the right and left ventricles. Following the intravenous injection of 35 per cent perabrodil or uroselectan B a single roentgenogram revealed opacification of the left ventricle at the same time as the right. The application of this method to older children and adults was made possible by the use of a more concentrated halogen compound (diodrast 70 per cent) by Robb and Steinberg[5] in 1938. Recently[6] we described a method for making a series of roentgen exposures during the course of a single injection which permits the right and left phases of the cardiac cycle to be recorded more completely. It is the purpose of this report to illustrate from a group of 65 congenital cardiacs the value of angiocardiography in the study of anatomic features and the physiologic dynamics of intracardiac shunts.

The intracardiac shunts may be divided into the following three types:

I. Interatrial septal defects
II. Interventricular septal defects
III. Transposition of the great vessels.

The last is included because the aorta arises from both ventricles, receiving venous and arterial blood simultaneously, and almost invariably an associated interventricular septal defect is present immediately below the origin of the aorta.

The embryology and pathological anatomy of these anomalies have been described completely by Maude Abbott[1] and need not be repeated. The important physiological principles involved may be summarized as follows:

I. The direction of flow through a shunt depends upon the pressure gradient between the chambers involved.
II. The volume of blood shunted depends, at least in part, upon the size of the communicating defect.
III. The presence or absence of clinical cyanosis depends primarily upon the degree of oxygen unsaturation of the systemic blood (over 6.7 volumes per cent in the presence of cyanosis).

Ordinarily in isolated and uncomplicated septal defects the direction of flow is from left to right. This occurs because the pressure within the chambers of the left side of the heart is considerably higher than that within the right cardiac chambers. However, if for any reason the pressure relationships are reversed, the direction of flow through the shunt is reversed and cyanosis may become manifest. In general, the latter occurs more constantly when the septal defects are associated with other congenital anomalies and especially with those of the pulmonary trunk.

The clinical diagnosis of intracardiac shunts is based upon the history, the localization and transmission of murmurs and bruits, the presence or absence of cyanosis, the roentgen configuration of the heart and

* Grateful acknowledgment is made to the Winthrop Chemical Company for the donation of the diodrast solution 70 per cent which was used in this study.
† Fellow of the Dazian Foundation for Medical Research.

great vessels, circulatory studies and the presence of electrocardiographic changes, especially axis deviation. Recently an objective method for determining the presence of a right to left shunt was described by Benenson and Hitzig.[2] This consists of the intravenous injection of a small amount of ether. In the presence of a venous arterial shunt, if sufficient ether enters the systemic circulation, peculiar paresthesias in the arms, legs and face are experienced by the patient.

We studied 18 instances of intracardiac shunts by means of angiocardiography which were grouped as follows:

Interatrial septal defects	10 cases
Interventricular septal defects	2 cases
Transposition of the great vessels	6 cases
(a) Tetralogy of Fallot (4 cases)	
(b) Eisenmenger's syndrome (2 cases)	

The clinical diagnoses were established on the basis of the criteria given in Table 1. In 2 cases, postmortem confirmation was available.

ANGIOCARDIOGRAPHIC STUDIES

The average normal time sequence of opacification of the cardiac chambers and great vessels is as follows:

Phase	*Structures Visualized*	*Time in Seconds from Beginning of Injection*
I	Superior vena cava, right atrium	0.5–1.5
II	Right atrium, right ventricle, pulmonary arteries	1.5–2.5
III	Right ventricle, pulmonary arteries	2.0–3.5
IV	Branches of pulmonary arteries and veins, left atrium	3.5–4.5
V	Pulmonary veins, left atrium, left ventricle, ascending aorta and aortic arch	4.5–7.0
VI	Left ventricle, entire aorta and branches	5.0–8.5

The discrepancy between these values and the circulation times as obtained by the use of ether, saccharine, decholine, calcium gluconate and sodium cyanide should be noted. An even greater discrepancy has been found in individuals with congestive heart failure and in cases with intracardiac shunts.

Cardiac shunts alter the pattern of angiocardiographic visualization resulting in either premature opacification, persistent opacification or recurrent opacification of the cardiac chambers and great vessels. Each group is considered in detail.

1. *Interatrial Septal Defects.* Uncomplicated cases of this lesion are usually associated with a left to right shunt since the left atrial pressure is normally higher than the right. During auricular systole, therefore, blood flows from left to right through the septal aperture. This increase in volume results in a higher pressure within the right atrium resulting in dilatation and hypertrophy. Any factor tending to augment the venous return may increase the right atrial pressure above that of the left and reverse the direction of the shunt, producing temporary or permanent cyanosis. Exercise, intercurrent pulmonary disorders and heart failure are the clinical conditions which may produce this phenomenon. Rapid intravenous injection of fluid may likewise temporarily reverse the direction of an interatrial shunt. Even a small volume of ether rapidly injected into the antecubetal vein may traverse the septal defect resulting in the characteristic paresthesias which occur when ether enters the systemic circulation. The rapid intravenous injection of 30 to 50 cc. of diodrast 70 per cent might be expected to produce a right to left shunt in the occasional case even though the usual flow is from left to right. That rapid injection may raise the right atrial pressure is suggested by the fact that regurgitation into the inferior vena cava and hepatic veins occurs in some of the anomalies and reopening of the foramen ovale in newborn children following the injection has been demonstrated by Castellanos *et al.* However, these phenomena were not observed in interatrial septal defects.

The expected angiocardiographic pattern in cases of interatrial septal defect with left-right shunt would include revisualization of the right auricle and ventricle after

TABLE I

	History			Physical Examination		
	Attacks of cyanosis	Development	Life span	Murmurs	Thrills	Clubbing
Interatrial Septal Defect	Occasional attacks of cyanosis during infancy. Permanent cyanosis may supervene with onset of heart failure, or severe pulmonary arteriosclerosis	Usually no retardation, either mentally or physically	Normal activity to 4th decade and even longer	Faint to loud systolic over 3–4 intercostal space left of sternum. Murmur has a peculiar high pitch. Occasionally early high pitched diastolic over pulmonary area. Presystolic rare. Murmurs may be entirely absent during childhood	2–4 intercostal space left of sternum	Usually absent
Interventricular Septal Defect	Rare; present only terminally	Frequent retardation, both physical and mental	Usually long	Harsh systolic over 3–4 intercostal space left of sternum transmitted to pulmonary and apical areas. May be absent during infancy and appear later in life	Occasionally present over sternum	Absent
Transposition of Great Vessels	Blue babies, or cyanosis may appear several months after birth	Frequent retardation both physical and mental	Death in infancy or childhood. Occasional cases reach adult life	Systolic over pulmonic area and 3–4 intercostal space left of sternum transmitted to right and down. Early diastolic over aortic area occasionally. Murmur may be absent or negligible in early childhood	Occasionaly over pulmonary area	Marked

the opaque material had reached the left heart. However, the demonstration would probably be difficult because of the already marked dilution of the contrast medium. Actually, demonstration of this type of shunt has not been achieved unequivocally, in our cases although in several a suggestion of persistent right auricular opacification was observed. On the other hand, in at least one case (Case 1) definite opacification of the left auricle was noted almost simultaneously with the right, suggesting that the sudden increase in right auricular pressure temporarily produced a right-left shunt. In one case which was examined at postmortem, the defect in the auricular septum was so large that the auricles appeared as one chamber. It is probable that in this case the structure interpreted roentgenologically to be right auricle actually represented both chambers although an abnormally early visualization of the left ventricle and aorta was not observed. The anatomic features in all of the cases were seen easily. These included:

(a) Marked dilatation of the right atrium, right ventricle, enormous (giant) pulmonary atteries and branches.
(b) Normal left ventricle.
(c) Hypoplastic aorta.

An enlarged left auricle was not seen regularly even in the presence of Lutembacher's syndrome although it was more common when the murmur of mitral stenosis was heard at the apex. Even under these circumstances the right heart remained proportionally larger than the left auricle. It must be remembered, however, that angiocardiography does not provide the precise size of the cardiac chambers if for no other reason than the likelihood that the opaque material does not fully fill the chambers.

II. *Interventricular Septal Defects.* (a) Isolated. In this type of septal defect the

Table I

Variants Associated lesions	Complications	Laboratory Data			Conventional Roentgen Findings
		Electrocardiogram	Circulation studies	Venous pulse	
Mitral stenosis (Lutembacher's syndrome)	Subacute bacterial endocarditis rare. Heart failure usually present several years before death	Right axis deviation. High voltage and widening of QRS. Inversion T_2 and T_3. Occasionally no abnormality	Ether test may be positive	Occasionally may be of arterial type	Enlargement of the heart to the left. Enormous dilatation of the pulmonary arterial system. Hilar dance. The esophagus is not displaced posteriorly by a large left auricle but may be by the large pulmonic vessels. Parodoxical systolic expansion of right atrium occasionally. Lutembacher's syndrome—enlargement of the heart to left, large pulmonic arteries, and evidence of left atrial enlargement
Patent ductus arteriosus Aortic stenosis	Subacute bacterial endocarditis common; heart failure uncommon	Usually left axis deviation. Occasionally no abnormality	Ether test usually negative	Normal	Globular heart with predominant left ventricular enlargement
Patent interventricular septum. Stenosis of pulmonary trunk and right ventricular hypertrophy (tetralogy of Fallot). Same but dilated pulmonary trunk (Eisenmenger's syndrome)	Subacute bacterial endocarditis infrequent. Heart failure fairly frequent. Pulmonary tuberculosis common terminally	Right axis deviation. High voltage QRS. Occasionally no abnormality	Ether test usually positive. Arm-to-lung equals arm-to-tongue time	Normal	Coeur en sabot. Peculiar configuration at apex—hump. Cardiac size may not be increased. Inconspicuous pulmonary arteries in tetralogy of Fallot and prominently dilated pulmonary artery in Eisenmenger's syndrome

pressure gradient between the left and right ventricles usually results in a left to right shunt. When the normal relationship between the left and right ventricular pressures is altered due to heart failure, etc., the shunt may be from right to left. This is most unusual and only occurs terminally.

By angiocardiography, in cases of isolated interventricular septal defect, revisualization of the right ventricle after it has emptied is to be expected. This was observed in the single case investigated (Case 11). The shunt will not ordinarily be reversed by the injection because the high pressure gradient between left and right ventricles probably will not be overcome by this means alone. The fact that only a single case was available for study is worthy of note but is compatible with other reported series. For example, Leech[4] discovered 2 interventricular septal defects in 18 congenital cardiacs older than two and one-half years. The lesion has been considered more common probably because differentiation from aortic and subaortic stenosis without the aid of an arterial pulse tracing is difficult.

(b) Complicated (associated with other congenital lesions). An interventricular septal defect occasionally is found associated with another congenital defect of independent embryological origin. In those instances in which the right intraventricular pressure is excessively high due to the presence of an associated stenosis of the pulmonary trunk, superimposed heart failure or pulmonary disease, the direction of flow is from right to left with resultant cyanosis. In such cases the angiocardiographic pattern also follows the right to left shunt, as will be described in the section on tetralogy of Fallot.

Where the associated lesion is on the left side consisting of subaortic or aortic stenosis, the normally existing left to right pressure gradient is increased and in such

instances the angiocardiographic pattern may be expected to show only a left to right shunt. The usual left to right shunt might be reversed by the injection where the associated lesion tends to increase the right intraventricular pressure, partially reducing the pressure gradient between the ventricles.

Not infrequently, the defect is plugged by bacterial vegetations (Case III). This complication will, of necessity, modify the angiocardiographic pattern and correct interpretation becomes impossible.

III. *Transposition of Great Vessels.* Due to embryological arrest of rotation the aorta may arise from the right ventricle entirely or from both ventricles. In the latter, it straddles the outflow of both ventricles and surmounts the interventricular septal defect. Thus, the venous blood passes into the systemic circulation and in effect there results a venous arterial shunt with cyanosis. Complete dextroposition of the aorta with the aorta arising from the right ventricle and the pulmonary artery from the left is imcompatible with long life. Occasionally complete atresia of the pulmonary artery in the presence of an interventricular septal defect may result in a similar but more indirect venous arterial shunt, the venous blood passing from the right ventricle through the septal defect to the left ventricle before it enters the aorta which arises normally.

Transposition of the aorta gives rise to the basic physiological disturbance in several more or less constantly associated cardiac defects which have been described as separate syndromes. The most common is the "tetralogy of Fallot." As originally described this tetrad consists of (*a*) overriding aorta or transposition of the vessels; (*b*) interventricular septal defect; (*c*) pulmonary artery stenosis; and (*d*) right ventricular hypertrophy. The variations of this syndrome are caused mainly by different degrees of aortic rotation. However, variants depend also upon the abnormality in the pulmonic trunk which may be either hypoplastic (atretic), normal or dilated. The dilated pulmonic trunk has been called the Eisenmenger complex.

The essential hemodynamics in all of these related syndromes depends mainly upon the partial flow of blood from the right ventricle into the aorta. The associated interventricular septal defect is secondary from the functional point of view. In this group, angiocardiography reveals simultaneous visualization of the right ventricle, aorta, pulmonic artery and left ventricle within two to three seconds of the beginning of the injection. The pattern is very characteristic because passage of the opaque material directly from right ventricle into the aorta results in unmistakable opacification of the latter; relatively little dilution occurs. In younger children in whom circulation is rapid, even normally, visualization of the entire aorta and the main thoracic arteries within two seconds after injection is the rule (Case IV). The density of the aorta is such that even the abdominal aorta and its main branches are clearly visualized. Since the size of the pulmonic artery is also demonstrated, angiocardiography usually permits precise classification within this group of congenital cardiac anomalies (Case V).

SOURCES OF ERROR IN INTERPRETATION OF ANGIOCARDIOGRAPHIC STUDIES

Errors may occur through technical variations or factors inherent in the dynamics of the individual case. The technical factors result from the injection as for example:

1. *Slow Injection.* If the duration of the injection exceeds two and one-half seconds, right-sided chamber visualization is prolonged and a left to right shunt may be simulated. The simultaneous opacification of both right and left chambers therefore may be found but may be differentiated from a shunt by noting the continuous opacification of the superior vena cava and right atrium throughout the cycle, i.e., at no time does the right side empty.

(2) *Interrupted Injection.* If the injection is interrupted due to mechanical difficulties, a re-opacification of the right chambers is produced which may simulate a shunt, the first phase of the injection having already

opacified the left chambers. The superior vena cava, however, will be noted to be opacified a second time.

(3) *Induced Shunts.* The rapid introduction of fluid may reverse the direction of flow of a left to right shunt. In such instances the usual direction of the shunt should dominate at the end of the cycle and be demonstrable at that time.

The circulatory factors which may occasionally result in misinterpretations or lack of visualization are as follows:

(1) *Rapid Circulation Time.* In young children, febrile illnesses and Graves' disease, the circulation may be so rapid as to result in early visualization of the left chambers even before emptying of the right chambers is complete. Bilateral opacification thus produced may lead to misinterpretation. However, this error can usually be avoided by careful studies of the serial exposures.

(2) *Marked Dilatation of the Cardiac Chambers.* Such dilution of the diodrast may result that opacification beyond the right ventricle is unsatisfactory.

(3) *Associated Valvular Stenoses.* The presence of a marked valvular stenosis may permit only small quantities of the blood-diodrast mixture to enter the chamber beyond the stenosis and result in insufficient opacification of the distal structures.

(4) *Continued opacification of the right chambers* may occur when the opaque material, having passed into the inferior vena cava and hepatic veins, returns to the right heart. Regurgitation into the inferior vena cava during an injection is a common phenomenon in congenital heart disease and in normal children. There is usually no clinical or laboratory evidence of tricuspid insufficiency.

(5) *The presence of vegetations* on the cardiac valves or septal defects may interfere with the passage of the opaque material.

DISCUSSION

The value of angiocardiography in congenital cardiac septal defects depends upon the demonstration of a shunt between right and left sides of the heart as well as the size of the cardiac chambers and great vessels. To demonstrate a shunt, the opaque material must pass through the abnormal channel in sufficient concentration to be distinguishable clearly despite the usual variations in the density and contrast of the roentgenogram which even the most careful technique does not exclude. Hence, the method is of greatest value when a right to left shunt is present more or less constantly, or in other words, in the presence of cyanosis. The absence of cyanosis indicates that the pressure in the left heart is greater than in the right. Therefore, the opaque material will pass into the left heart already diluted before it is shunted back into the right to be diluted more. Occasionally, however, pressure conditions are such that the added volume of opaque material injected rapidly is sufficient temporarily to induce a right to left flow. It is evident, therefore, that angiocardiography occupies a position in diagnosis similar to any other laboratory procedure. Accurate clinical diagnosis is possible in most cases of intracardiac shunts without recourse to the method. However, in the individual case, confirmatory evidence is obtained which may be valuable. Occasionally, for example, interatrial septal defect is mistaken clinically for patent ductus arteriosus. Since the latter is amenable to surgery, any aid in differential diagnosis is important. The value of angiocardiography is only partially impaired when shunts are not demonstrated unequivocally. The fact that cardiac enlargement is due to right rather than left heart dilatation is demonstrated conclusively. These anatomical features are often an indication of the severity of the abnormality and, with the better understanding of the pathological physiology, are likely to be of assistance in determining prognosis.

Angiocardiography is of particular value in the Eisenmenger complex because with conventional roentgenography the large pulmonary artery may obscure the presence of a dextroposed aorta. Fortunately, the simultaneous visualization of aorta and

pulmonary artery soon after injection is quite clear.

The disparity between circulation times and the times when right and left hearts are opacified is difficult to explain. The disparity is particularly marked in the presence of a cardiac shunt. The problem is presumably related to the difference in the concentrations of the various agents required to produce the desired effect.

REPORT OF CASES

CASE 1. *Interatrial Septal Defect; Induced Right to Left Shunt.*

J. S. (No. 484630) (Service of Dr. Eli Moschcowitz). A Negro, aged thirty-five, was admitted to Mt. Sinai Hospital for surgical ligation of patent ductus arteriosus which had been diagnosed clinically at another institution. At two years of age he had lobar pneumonia and acute purulent otitis media which were treated in a hospital. No cardiac abnormality was noted at that time. At the age of ten and twelve he suffered attacks of fever associated with painful swelling of the left knee. At the age of twenty-nine he was operated on for removal of a bullet; at this time he was told of a cardiac condition. Two years previously he began to have symptoms of congestive heart failure. He was hospitalized and in addition to the cardiac lesion, chronic pulmonary tuberculosis was discovered.

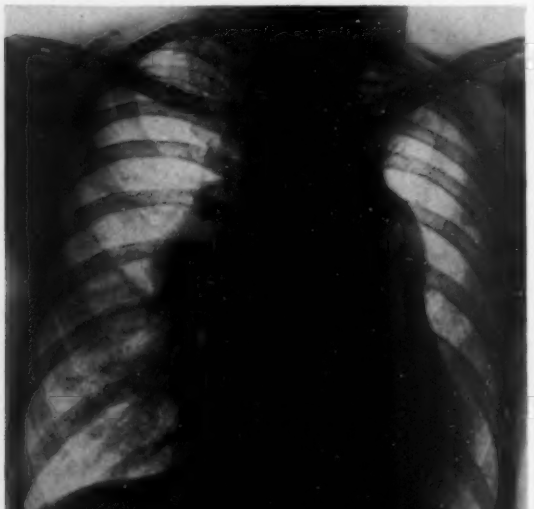


FIG. 1. *Interatrial septal defect.* Case 1. Conventional posteroanterior roentgenogram shows enormous dilatation of pulmonary artery segment of left cardiac contour and associated giant pulmonary artery branches. Heart enlarged both to left and right. Bilateral apical fibroid tuberculosis.

Physical examination revealed a dyspneic colored man. The heart was enlarged at the

FIG. 2. *Interatrial septal defect.* Case 1. Angiocardiogram taken in left anterior oblique position two and one-half seconds after beginning of injection. A fan-shaped area of opacification is present in the region of the left atrium. Temporary distention of the right atrium produced a right to left shunt.

second left interspace. The point of maximal impulse was felt 1 cm. to the left of the midclavicular line. There was a systolic thrill over the pulmonic area; blowing systolic and diastolic murmurs were heard over the entire precordium, especially marked over the pulmonic area. There was dullness over the left upper lobe; the breath sounds were diminished over this area.

Blood pressure was 116/100. The liver edge was felt three finger breadths below the costal margin.

Laboratory Data. Blood count was within normal limits; hemoglobin, 101 per cent. Urine showed varying amounts of albumin.

Blood serology and chemistry were negative. The electrocardiogram showed right axis deviation; RT_2 and RT_4 depressed; T_2 and T_3 inverted. Phonocardiogram showed a high-pitched systolic murmur over the pulmonic area and an early diastolic murmur over the apex.

Roentgen examination of the chest showed calcific and fibrotic tuberculous infiltration of both upper lobes. The cardiac configuration suggests interauricular septal defect (Fig. 1).

Circulation Studies. Vital capacity 1,500 cc.; venous pulse, 22 cm. of blood; ether, 14 sec. (no peripheral manifestations). Saccharine time, 30 sec.

Angiocardiography showed marked dilatation of the right auricle and ventricle. Almost immediately after the beginning of the injection there was opacification in the region of the left auricle. There was marked dilatation of the main pulmonary artery and its major branches, with a sharp transition in caliber to the secondary branches of the left pulmonary artery, the smaller branches of which were not visualized (Fig. 2), possibly due to thrombosis.

These findings were interpreted as indicating the presence of an interatrial septal defect with an induced right to left shunt.

The patient was successfully treated with digitalis and mercurial diuretics with disappearance of all signs of cardiac failure and he was discharged from the hospital.

Final Discharge Diagnosis: congenital heart disease—patent interatrial septal defect, dilatation of pulmonary artery, possible Lutembacher's syndrome (associated congenital mitral stenosis); possible superimposed rheumatic heart disease, mitral stenosis; congestive heart failure; possible thrombosis of branches of left pulmonary artery; chronic fibroid pulmonary tuberculosis.

Case II. *Isolated Interventricular Septal Defect; Left to Right Shunt.*

N. Y. (No. 474579) (Service of Dr. Bela Schick). A white male child, aged eight, was referred for angiocardiographic studies. He had appeared somewhat underdeveloped physically compared to the other siblings, otherwise he had been in good health. At the age of four years he had lobar pneumonia and at this time the attending physcian noted a cardiac abnormality.

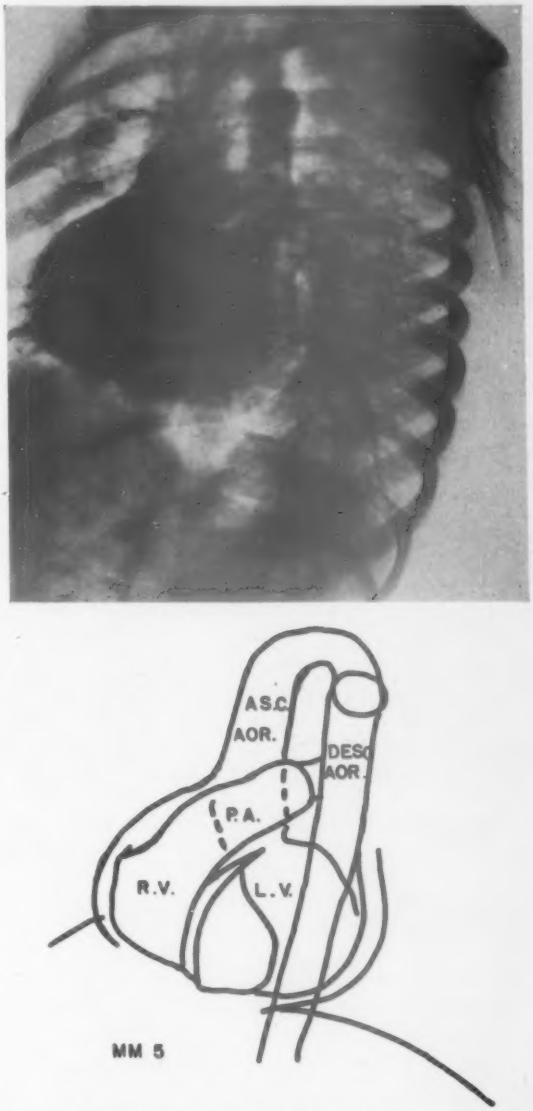
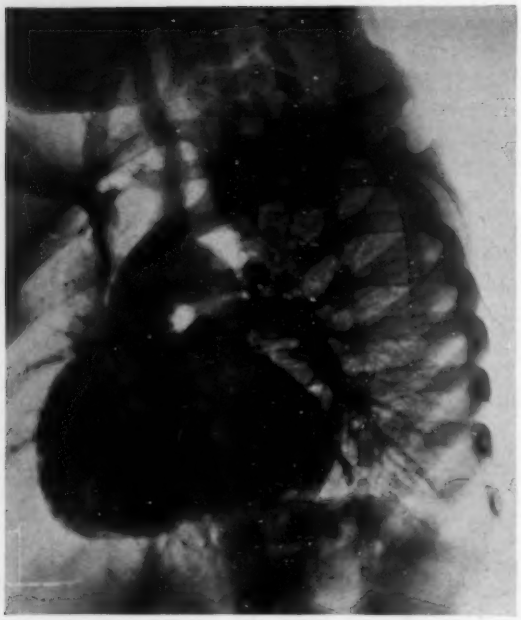


Fig. 3. *Interventricular septal defect.* Case II. Angiocardiogram taken in left anterior oblique position four and one-half seconds after beginning of injection. This shows simultaneous visualization of both ventricles indicating re-opacification of the right ventricle. The latter was seen in previous roentgenogram to have emptied.



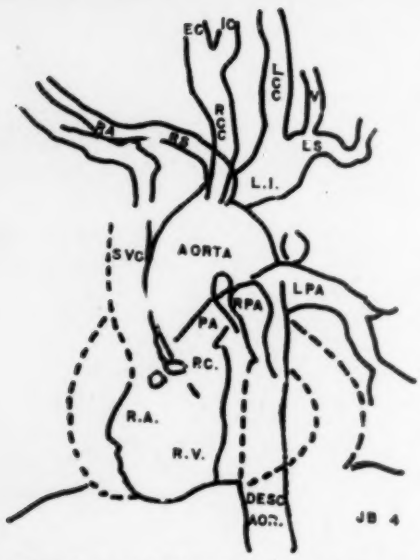


FIG. 4. *Tetralogy of Fallot with right sided aorta.* Case IV. Angiocardiogram taken in left anterior oblique position two seconds after beginning of injection. Complete visualization of entire cardiovascular system indicates transposition of the great vessels as well as an interventricular septal defect. The pulmonary artery is stenotic. In the posteroanterior position the arch and descending aorta were seen to the right of the spine.

Physical examination revealed an underdeveloped but healthy white boy. There was no evidence of cyanosis or clubbing of the digits. The heart was not enlarged to percussion. A loud rough systolic murmur and thrill were present maximally over the mid-sternum.

Blood pressure was 100/70. First degree hypospadias was noted.

Laboratory Data. Hemoblobin 14.5 gm. Urinalysis and blood chemistry, negative. Electrocardiogram showed left axis deviation. QRS of high voltage, suggestive of enlargement of the left ventricle.

Phonocardiogram revealed high-pitched systolic murmur of high amplitude occupying entire systole, best heard at left sternal border between the third and fourth intercostal spaces.

Angiocardiography revealed a re-opacification of the right ventricle four seconds after injection simultaneously with the opacification of the left ventricle. The chambers were moderately dilated. Reflux into the inferior vena cava was noted (Fig. 3).

CASE III. *Complicated Interventricular Septal Defect. Associated Pulmonic Insufficiency due to Congenital Deformed Pulmonic Valve Leaflet. Vegetation of Subacute Bacterial Endocarditis. Occluded Septal Defect, No Shunt Demonstrated.*

E. A. (No. 471053) (Service of Dr. Harold Neuhof). A white male, aged thirty-three, was admitted to Mt. Sinai Hospital for surgical ligation of patent ductus arteriosus. Although he had known of the presence of a cardiac murmur since early childhood, he had led a normal active life until the onset of this illness about nine months previously. At that time he began to have chills, fever, pain in the chest and bloody expectoration. He was hospitalized elsewhere and numerous blood cultures grew many colonies of *Streptococcus viridans*. A diagnosis of patent ductus arteriosus with superimposed subacute bacterial endarteritis had been made.

Physical examination revealed a febrile, dyspneic, emaciated young man. Marked cervical pulsations were present.

The heart was enlarged to the left. A marked systolic and diastolic thrill was felt over the pulmonic area, less distinctly over the apex. The point of maximal impulse was in the sixth intercostal space, slightly beyond the midclavicular line. Over the pulmonary area there was heard a loud blowing low-pitched systolic murmur and a faint high-pitched diastolic murmur (machinery type). The blood pressure was 100/70.

The spleen was felt two finger breadths below the costal margin. Several Osler's nodes were present on the fingers.

Laboratory Data. Blood count revealed a secondary anemia; hemoglobin 60 per cent; leukocyte count 29,400 with 87 per cent polymorphonuclears. Urinalysis showed albumin and red blood cells.

Blood cultures revealed numerous colonies of *Streptococcus viridans*.

Blood urea nitrogen on admission was 9 mg. per 100 cc. and rose to 54 mg. per 100 cc.

Circulation time: saccharine, 15 sec.; venous pulse, 16 cm. of blood.

Electrocardiogram showed left axis deviation, sinus tachycardia.

Phonocardiogram: very prominent high-pitched musical murmurs over entire precordium occupying entire systole and loudest at the pulmonic area. There was present also a fainter late diastolic murmur. A presystolic gallop was demonstrated.

Angiocardiography: right auricle and ventricle are not distinctly abnormal in size. Main pulmonary artery and left pulmonary artery appear dilated. The left ventricle is not sharply outlined. The aorta is of normal caliber but shows a slight dilatation of the descending portion.

Surgical exploration and postmortem inspection of the heart were performed. No ductus arteriosus was found. There was an interventricular septal defect measuring 2 by 2.5 cm. situated in the superior portion of the membranous septum. The aperture was completely occluded by bacterial vegetations. In addition, there was an anomaly of the posterior leaflet of the pulmonic valve resulting in pulmonary insufficiency. Bacterial vegetations were present on the pulmonic and tricuspid valves. The pulmonary artery was markedly dilated. The right ventricle was both hypertrophied and dilated.

Case iv. *Tetralogy of Fallot and Right Aortic Arch.*

J. B. (No. 476580) (Service of Dr. Bela Schick). White female, aged four, who had been cyanotic since birth. Convulsions of jacksonian type had been present since one year of age. Mental development was normal. Dyspnea occurred on exertion with orthopnea. The child became extremely cyanotic on crying.

Physical Examination. Normal size and weight. Lips and mucous membranes were darkly cyanotic. There was marked clubbing of all digits.

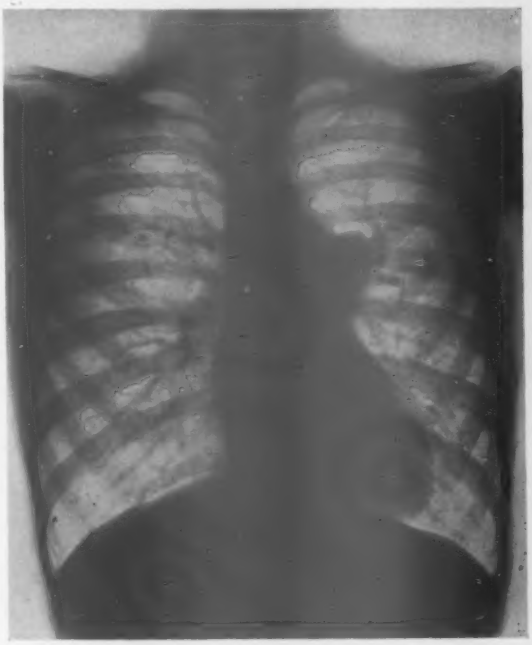


Fig. 5. *Eisenmenger's complex.* Case v. Conventional posteroanterior roentgenogram showing peculiar double contour in the region of the pulmonary artery segment of the heart.

Laboratory Data. Hemoglobin 159 per cent, 22.9 gm. Red blood cells, 12,850,000; leukocytes, 11,800. Blood pressure 108/70. Electrocardiogram: sinus tachycardia; marked right axis deviation; P waves very high; QRS, high voltage; RT 1, 2, 3 depressed; T 3 inverted. The changes suggested enlargement of the right auricle and ventricle.

Phonocardiogram revealed very short early systolic murmur of low amplitude over pulmonic area.

Angiocardiography revealed simultaneous opacification of aorta and pulmonary artery two seconds after injection. The right heart was moderately enlarged. The pulmonary artery was small. The aorta was dilated. The arch and descending aorta passed to the right of the spine (Fig. 4).

Case v. *Eisenmenger's Complex.*

B. W. O. (Referred by Cardiac Clinic, Montefiore Hospital, New York City). Male, aged twelve. The patient has been moderately cyanotic since earliest childhood. There were no symptoms of diminished cardiac reserve. Development has been normal.

Physical Examination. Blood pressure 100/

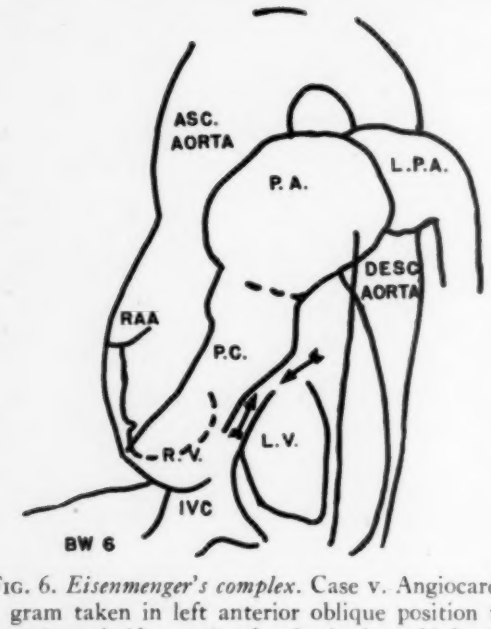


FIG. 6. *Eisenmenger's complex.* Case v. Angiocardiogram taken in left anterior oblique position two and one-half seconds after beginning of injection. Simultaneous opacification of right ventricle, pulmonic artery and aorta indicates that both great vessels arise at least in part from this ventricle. The left ventricle is only partially opacified through the patent interventricular septal defect. The main pulmonary artery and its left branch are markedly dilated.

65. Slight clubbing of all digits. All fingernails were markedly curved (Fig. 5).

Laboratory Data. Electrocardiogram showed regular sinus rhythm. Marked right axis deviation. P waves notched and prominent in leads 2 and 3. QRS of high voltage. These changes suggest enlargement of the right auricle and ventricle.

Phonocardiogram revealed prolonged high pitched systolic murmur of high amplitude present over entire precordium, maximum over the pulmonic area.

Angiocardiogram revealed simultaneous opacification of pulmonary artery and aorta two and one-half seconds after the beginning of injection. The pulmonary artery was markedly dilated (Fig. 6).

CONCLUSIONS

Sixty-five congenital cardiacs have been subjected to angiocardiography. Eighteen cases represented various types of intracardiac shunts. The method usually demonstrated the shunt when a right to left shunt existed and sometimes when it was produced by the injection. In other cases, when the shunt was left to right, re-opacification of the right heart could be made out occasionally. In all cases, the demonstration of the pathological anatomy and physiology present was of value in differential diagnosis. It is likely that with additional data better evaluation of prognosis will be possible.

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MILIARY CALCIFICATION OF THE LUNG*

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MILIARY calcification of the lung† is fairly frequently encountered by roentgenologists in routine chest surveys and has been the occasion for numerous reports in the past. The condition has been generally considered[1,6,8] to be caused by tuberculosis but several authors have raised the question of other etiological factors. Sutherland[11] believed that it might be related to over-saturation of the blood by calcium salts associated with some metabolic anomaly. Sayers and Meriwether[10] cultured fungi, namely the *Aspergillus*, from the sputum of a number of such cases and felt that the picture could be reproduced by that type of infection. Olson, Wright and Nolan[7] reported results of a Public Health investigation in Ohio and considered the *Ascaris* as a possible cause where tuberculosis could be ruled out. Their study, however, failed to prove or disprove that this parasite was the causative agent. In none of the above reports were pathological studies made. This is understandable since many of the cases were in good health and opportunity for continuous follow up to death and autopsy examination was not available.

The purpose of this report is to present the results of pathological and bacteriological studies in two typical examples of this condition. Both patients died of entirely unrelated diseases and complete autopsy examinations were performed.

Case 1. W. S., male, aged seventy-six, was admitted to Colorado General Hospital on October 30, 1941, complaining of weakness, diarrhea, numbness and tingling of the hands and feet and a loss of 15 pounds in weight, all taking place during the past three months. He stated that he had been under treatment for pernicious anemia periodically during the previous ten years. He had been admitted to this institution on two other occasions, 1937 and 1940, for treatment of that condition. The physical examination on admission at this time revealed old varicose ulcers, external hemorrhoids and bilateral indirect inguinal herniae.

The laboratory studies showed: *urinalysis*: 2+ pus cells; *blood*: erythrocytes 4,510,000, hemoglobin 14.0 grams; *blood chemistry*: nonprotein nitrogen 49, urea nitrogen 25 and creatinine 1.7 mg. per 100 cc.

Roentgen examination of the chest demonstrated miliary calcified lesions distributed evenly in both lung fields. They varied in size from 1 to 3 mm. in diameter. The hilar nodes showed bilateral extensive calcification (Fig. 1).

Fig. 1. Case 1. Showing miliary calcified lesions distributed evenly in both lung fields. The hilar nodes display extensive calcification.

Clinical Course. Shortly after admission the patient developed fever which fluctuated between 101.2° and 103.4° F. His course was rapidly retrogressive. Tuberculin skin testing with 0.1 cc. of 1:100,000 O.T. was performed and found to be negative. Death occurred before a subsequent examination with a higher con-

† Also called "miliary calcicosis," "miliary calcinosis" and "wheatena." The latter term has arisen because of the fairly high incidence among workers in wheat fields.

* From the Department of Pathology, University of Colorado, School of Medicine and Hospitals.

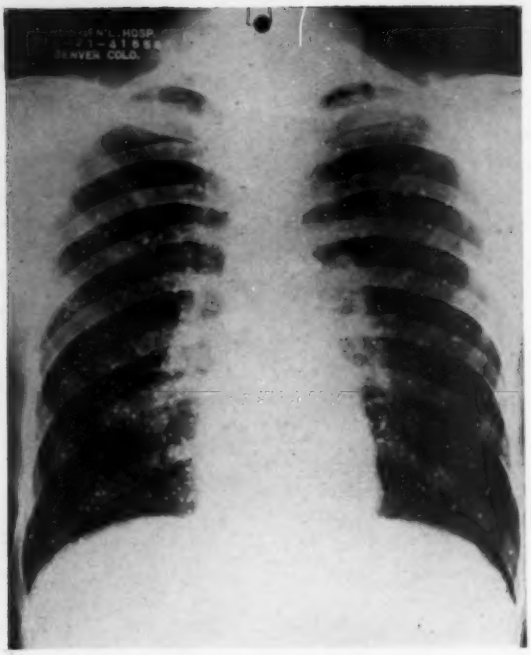

FIG. 2. Case II. Miliary lung calcifications varying from 1.0 to 3.0 mm. in diameter. Hilar nodes are extensively calcified.

centration of O.T. could be carried out. The patient died on November 3, 1941.

Autopsy was performed two hours postmortem and revealed the following significant findings: (1) hypostatic terminal pneumonia, bilateral, moderate; (2) ulcerative ileitis, subacute, moderate, cause undetermined; (3) prostatic hypertrophy, obstructing, moderate; (4) cystitis, subacute, with multiple diverticula, secondary to (3); (5) nephrosclerosis, senile, arterial type, moderate; (6) multiple miliary lung calcifications, bilateral, with secondary bilateral hilar lymphadenitis. The pathological lung findings will be described in detail later.

CASE II. D. M., male, aged thirty-six, was admitted to Colorado General Hospital on January 6, 1941, complaining of shortness of breath and weakness during the past six months, and swelling of the lower extremities for two weeks. He had lost 13 pounds in weight during the latter period. The significant physical findings were ascites, enlargement of the spleen and moderate emaciation.

The laboratory studies revealed: *blood*: erythrocytes 1,100,000, leukocytes 134,400; the differential count showed 35 per cent mature polymorphonuclears, 52 per cent immature myeloid forms, 8 per cent lymphocytes, 3 per cent eosinophiles and 2 per cent basophiles.

Roentgen examination of the chest was performed and demonstrated findings similar to those in Case I. Numerous calcifications varying from 1 to 3 mm. in diameter were distributed evenly over both lungs. The hilar region bilaterally showed extensive calcification (see Fig. 2). The sputum was found to be negative for tubercle bacilli on smear examination and after guinea pig inoculation. Sputum culture on Sabouraud's medium for fungi was also unsuccessful.

Clinical Course. A diagnosis of myelogenous leukemia was made and the patient given several courses of roentgen therapy. Response was satisfactory and he was discharged shortly thereafter. He was readmitted on October 20, 1941, complaining of a return of all the old symptoms, i.e., weakness, shortness of breath and swelling of the legs. Tuberculin skin testing was carried out at this time with 0.1 cc. of 1:100,000 O.T. The test was negative and was repeated later with 0.1 cc. of 1:10 O.T. The latter examination was also negative. Blood study on admission revealed erythrocytes 2,850,000 and leukocytes 114,250. His course was steadily retrogressive and death occurred on November 14, 1941.

Autopsy was performed nine hours postmortem and presented the following positive findings: (1) myelogenous leukemia with hepatomegaly (2,840 grams), splenomegaly (1,550 grams) and myeloid hyperplasia of the bone marrow; (2) chronic organizing pneumonia, severe, bilateral, upper lobes; (3) leukemic in-

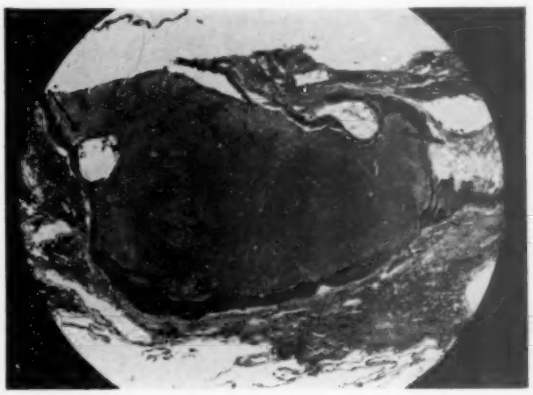

FIG. 3. Case I. Low power (magnification 32×) section of a lesion showing almost complete encapsulation by bone with several marrow foci as indicated.

filtration into the lungs, spleen, liver and adrenals; (4) multiple miliary lung calcifications, bilateral, with secondary bilateral hilar lymphadenitis.

The Pulmonary Lesions

CASES I AND II

The changes in both cases were identical and will be described jointly. Both lungs were

Fig. 4. Case I. Another lesion (magnification 145×) demonstrating rhythmic banding, similar to Liesegang's rings, in the central caseous and calcified area; also some marginal ossification.

seeded with many small, hard lesions which were apparent only as they approximated the visceral pleura. In the cut section palpation provided a more accurate impression of their size and character than did visualization. The nodules varied in size from 1.0 to 3.0 mm. in diameter. They were stony hard in consistency and could not be sectioned with a knife; crushing with bone forceps revealed a dry, yellowish-white, amorphous composition. The tracheobronchial lymph nodes, bilaterally, were moderately enlarged and matted together. They were extensively involved by stony hard, yellowish-white infiltrations. The liver and spleen in both patients were not similarly affected.

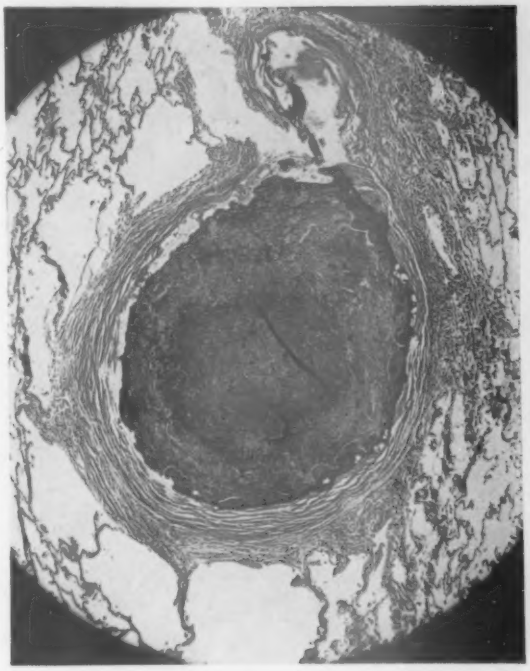

Fig. 5. Case II. Low power (magnification 32×) section of a lesion showing approximately two-thirds encapsulation by bone. Central caseation and calcification are demonstrated also.

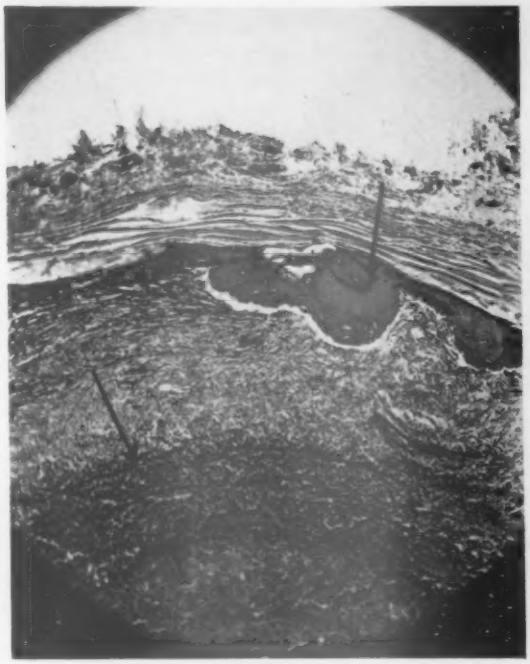

Fig. 6. Case II. Another lesion (magnification 145×) with rhythmic banding and a bony margin as indicated.

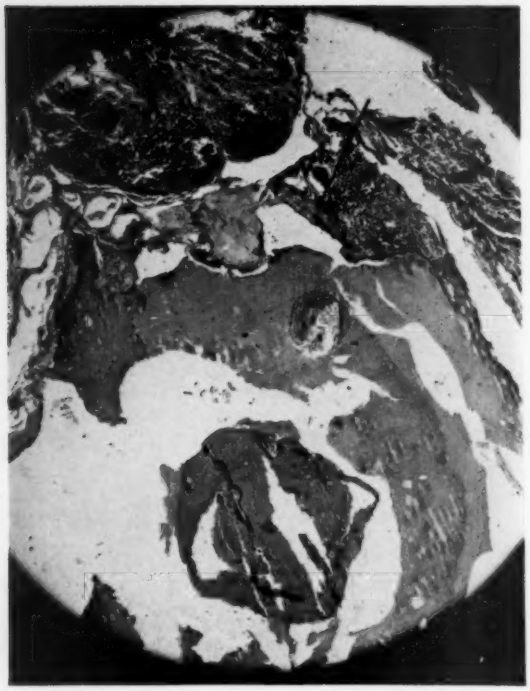

FIG. 7. Case I. Low power (magnification 32 ×) section of hilar lymph node demonstrating central caseation and calcification. Marginal fibrosis is indicated.

Bacteriological Examination. Individual lung lesions as well as specimens of hilar lymph node were removed aseptically and ground up under sterile conditions in a mortar. Digestion was then carried out with weak alkalies, and the sediment stained and examined for tubercle bacilli. Furthermore, the neutralized sediment was injected into a guinea pig. In Case II, additional culture on Sabouraud's medium was undertaken for fungi. The bacteriological studies and autopsy examinations of the inoculated guinea pigs were negative.

Microscopic Pathological Studies. Large sections of both lungs were preserved in Lundquist's solution* and after thorough fixation the individual lesions were isolated and decalcified with mineral acid (5 per cent HNO_3). Each nodule was then carefully sectioned as close to the center as possible and embedded in paraffin. Staining was then carried out with hematoxylin and eosin and carbol-fuchsin. Photomicrographs of the lung sections are provided at different magnifications in Figures 3 to 6. Ten lesions were prepared in the above manner from each case. They exhibited central caseation and varying degrees of calcification, sometimes in concentric layers.* In the periphery, almost every nodule (7 out of 10 in Case I, and 8 out of 10 in Case II) showed ossification of its fibrous capsule. In some instances bone marrow and hematopoiesis could be distinguished. There was no marginal inflammatory reaction although a few epithelioid cells, lymphocytes and plasma cells were occasionally observed. All lesions appeared completely healed. No organisms, i.e., fungi or acid fast bacilli, were noted in either the hematoxylin and eosin or carbol-fuchsin stained sections. The hilar lymph nodes in both cases

FIG. 8. Case II. Low power (magnification 32 ×) section of hilar lymph node showing same features as Figure 7.

* Dr. James J. Waring has called my attention to the resemblance of this concentric layering to Liesegang's phenomenon.

* Lundquist's Solution I

For 12 hours or longer dependent on size of section	potass. acetate	35.0 gm.
	potass. nitrate	45.0 gm.
	chloral hydrate	80.0 gm.
	formaldehyde	444.0 cc.
	water	4000.0 cc.

Lundquist's Solution II

For indefinite storage	potass. acetate	10.0 gm.
	chloral hydrate	5.0 gm.
	glycerin	10.0 cc.
	hot water	90.0 cc.

also presented similar changes which differed only in the absence of peripheral ossification (Fig. 7 and 8).

DISCUSSION

The possibility that diseases other than tuberculosis may cause miliary lesions in the lungs cannot be denied. Some of the etiological factors suggested on the basis of studies in humans have already been referred to. Experimentally, Cronkite and Lack[3] reproduced the picture to some extent in guinea pigs by having the animals inhale dry mycelial spores of *Coccidioides immitis*. The early lesions were translucent, grayish nodules up to 2 mm. in diameter and proved to be granulomata microscopically. Epithelioid cells, occasional multinucleated giant cells and several typical spherules of coccidioides could be distinguished in such granulomata. In the 2 cases presented here the most likely diagnosis, in my opinion, appeared to be healed miliary tuberculosis of the primary type. This interpretation was made on the basis of the close resemblance of the lesions to healed Ghon tubercles and because of the extensive regional (hilar) lymph node involvement. The negative tuberculin tests and bacteriological studies were not considered to be decisive objections to this diagnosis. The question of tuberculo-allergy becoming spontaneously extinguished in healed tuberculosis is controversial. However, it can be stated as fairly well accepted that the sensitivity may be depressed in patients in a cachectic state whether the latter is due to tuberculosis or other diseases. In such cases a tuberculous focus could exist with a negative tuberculin reaction. The test was performed two days before death in Case I, in Case II ten days before death. The absence of bacteriological verification is also not unusual in old healed tuberculous lesions. Feldman and Baggenstoss,[4] for example, found viable organisms in only 1 case out of 68 subjects in whom the lesions of the primary complex were examined for tubercle bacilli.

Bone formation in tuberculous foci is of particular interest and is frequently observed in primary tuberculous lesions found in routine autopsy examinations. Boyd[2] considered ossification in lung or lymph node lesions as an indication of a primary tuberculous infection. Terplan[14] found that 60 per cent of all primary foci in his adult series contained bone. Puhl[9] also stressed bone formation as very frequent in healed primary lesions (50 per cent in his group). Although the latter author admitted that reinfection lesions might run through the same sequence of changes, bone formation was only rarely observed. Sweany,[12] on the other hand, interpreted the presence of bone as an indication merely of extreme age of a tuberculous lesion and stated that ossified foci are at least ten years old. Sweany[13] also pointed out that "There is no absolute way of telling a primary lesion by pathological appearances alone." The presence of bone in a tuberculous focus is probably not specific for a primary infection, although it is commonly found in such lesions. In the 2 cases described, however, the combination of ossified foci and extensive regional (hilar) lymph node involvement would appear to justify an interpretation of a primary type of infection. The latter had undoubtedly taken place a long time ago, probably in infancy or childhood, and had resolved in complete healing. In no respect had the condition contributed to the fatal issue in either patient.

For future clarification of this problem it is recommended that the following studies* be performed whenever an opportunity presents itself to examine a patient who demonstrates this finding in a chest roentgenogram.

Clinical

(1) History of contact with tuberculosis.
(2) History of pulmonary tuberculosis.
(3) Determination of tuberculo-allergy by tuberculin skin testing.

* The value of chemical analysis is doubtful as pathologically calcified tissue has approximately the same composition whether produced in tuberculosis or in the course of other diseases (Maver and Wells[6]).

Bacteriological

(1) Sputum studies
  (a) Culture for tubercle bacilli.
  (b) Culture for fungi.
  (c) Guinea pig inoculation.

(2) Autopsy lesions
  (a) Culture for tubercle bacilli.
  (b) Culture for fungi.
  (c) Guinea pig inoculation.

Pathological

(1) Gross morphology including examination of the regional lymph nodes.
(2) Microscopic study.

Roentgenological examination—periodic chest roentgenograms to establish or rule out progression of the lesions.

CONCLUSIONS

1. Two cases of miliary calcification, discovered incidentally in routine chest (roentgen-ray) examinations, were studied clinically, bacteriologically and pathologically.

2. The complete study suggested the cause for the appearance in the two cases to have been tuberculosis, probably of the primary type.

3. The infection had occurred many years previously, probably in infancy or childhood, and had completely healed. The condition in no way contributed to death in either case.

4. Although the possibility exists that other agents may cause this interesting lung picture, the importance of tuberculosis should not be minimized.

The author wishes to express his appreciation to Dr. James J. Waring and Mr. Donald E. Cummings for their cooperation and suggestions in this study.

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VOL. 49, NO. 6

LAYER FORMATION IN PYELOGRAPHY

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PYELOGRAPHY in general has not as yet developed to such a degree of perfection that its results have the same degree of diagnostic reliability as the results in other fields of roentgenology. One needs only to glance over the pages of one Quarterly Cumulative Index Medicus to find that every year several articles are published with the title "Pitfalls in Urography."

We have to ask ourselves whether these pitfalls are due to inherent limitations of the method employed, or whether by technical improvements or better knowledge of interpretation these pitfalls can be diminished. Well known is the fact that a normal pyelogram may be obtained in the presence of a malignant tumor.[22] If a tumor starting in the cortex of the kidney has not yet deformed the renal pelvis, we will be unable to demonstrate it by pyelography. It is immediately obvious that we are facing here an inherent limitation of the method. We should not be more disappointed about this diagnostic failure than we are about our inability to demonstrate tumors in other parenchymatous organs. There are, however, other failures of diagnostic accuracy in pyelography which we believe can be avoided by a more careful technique and interpretation.

In this paper we shall try to demonstrate one possible source of error in interpreting pyelograms and a method of avoiding such errors. First, a word may be said in regard to the merits and the diagnostic value of the retrograde and intravenous methods. A great many papers[6,23,24] have been published evaluating the indications for either method and the results obtained. There is a surprising lack of unity of opinion in regard to this subject, as one can readily see by statistics published by Cumming and Chittenden.[5]

It has been claimed that intravenous pyelography frequently does not give as exact anatomical detail as retrograde pyelography. We feel that by recent technical improvements in intravenous pyelography, mainly the use of compression, the method has been improved to such an extent that this claim is no longer valid.

There have been numerous papers published in recent years about compression technique. Compression was recommended many years ago by Ziegler,[35] but a wider application of the method has taken place only in the last several years.[1,10,12,19,25,28,29] The method of using compression varies. Our method consists in using a cellucotton roll and then the ordinary Bucky compression band to exert considerable pressure over the lower abdomen in the region where the ureters cross over the rim of the bony pelvis. It is essential to apply the compression very tightly; if this is done gradually, the patient does not suffer much discomfort. As a rule, the compression is applied for about twenty minutes. This time is usually sufficient to give a good anatomical outline of both renal pelves and the upper portions of the ureters. If excretion is delayed, or if the amount of dye excreted in that time is not sufficient to give a satisfactory shadow of a dilated renal pelvis, as in hydronephrosis, compression is sometimes applied longer. Then the compression is released and the next roentgenogram is taken immediately. This results very often in an excellent demonstration of the entire length of the ureters, because the dye which has been dammed back by the compression immediately rushes down toward the bladder, filling the lower portions of the ureters. After this, roentgenograms are taken without compression. Thus the artificial stasis is eliminated and subsequent roentgenograms give a true picture of the physiological status of the renal pelves and ureters. Many authors object to compres-

sion, calling it an unphysiological method.[30] If this combined technique is used, the objections to compression as an unphysiological method are no longer valid.

It is important to discuss briefly the changes in the pyelogram due to the compression itself, as they may have some bearing on interpretation. It should be stated that in normal animals compression passing, it may be noted that compression is often more effective on the right side than on the left, due to the anatomical differences in the positions of the ureters.[1] As already mentioned, on the pyelograms taken after release of compression both ureters are often demonstrated *in toto*. This is the usual occurrence, and has to be considered normal when this method is used.[2]

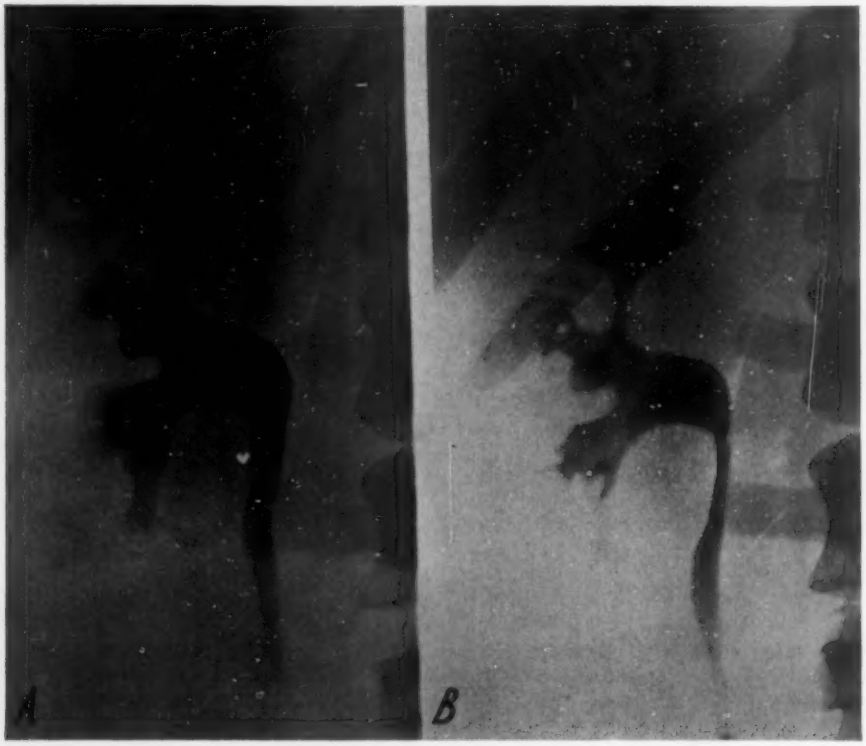


FIG. 1. *A*, normal renal pelvis with compression. *B*, same renal pelvis immediately after release of compression. Note decrease in width of pelvis and ureteropelvic junction.

longer than forty minutes may delay excretion of the dye.[10,33,34] Since the usual examination for diagnostic purposes does not exceed this time, there is no interference with the excretion of dye. The calices and the pelves will appear wider with than without compression, but never to such a degree as to interfere with the interpretation. If one has any doubt whether the renal pelves are of normal width in a given case, comparison with the pyelogram taken without compression will be helpful (compare *A* and *B*, Fig. 1). In pyelography *without* compression, a completely filled ureter is considered a sign of a pathological change, as normal peristalsis interferes with complete visualization of the ureter.[4,7]

The value of compression has been demonstrated by some statistics.[17,23,25] Table 1, taken from Reitan's[25] article, shows that retrograde pyelography was superior to intravenous pyelography with compression in only a limited number of cases.

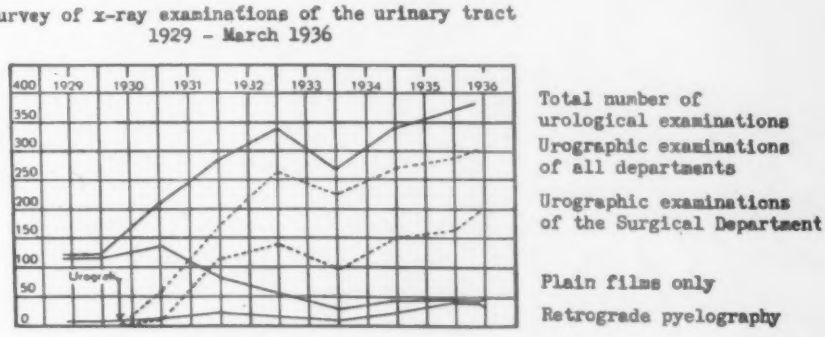
Reitan[25] also has published a chart showing the enormous increase in urological

Table I*

Cases Examined		Diagnostic Results				Retrograde Pyelography		
Diseases	Number operated upon	Correct (type of diagnosis)	Sum	Essentially correct	Wrong or indefinite	Examination unsatisfactory	Gave necessary correction	Determination of pathological side without retrograde pyelography
Renal tuberculosis	49	28	42	14	7	14	0 (8, 4 of which were controls of the normal side)	47 %
Hydro- and pyonephrosis (without stones)	12	5	8	3	4, all as "tumor" diagnosis (large kidney without contrast)		4 (6)	12
Stones	67	66	66		1			67
Renal tumors	19	15	18	3	1	1	8 (11)	18
Renal cysts	4	1	3	2	1	1	0 (3)	4
Bladder tumors	3	2	2		1	1	0 (2 cystographic examination)	

* From Reitan.[25]

examinations by the use of intravenous urography since the technique has been perfected (Chart 1). From this chart it is evident that the examination has been extended to many conditions which would not have been definite enough to warrant



Only plain films	117	137	83	51	27	42	44	12:	344
Retrograde pyelography .	7	11	22	18	14	24	40	11:	132
Intravenous urography. .	0	58	171	263	225	268	285	94:	1364
Total no.of.examinations	124	209	284	337	268	338	370	117:	1862

Chart I*

* From Reitan.[25]

retrograde pyelographic studies, but which, after examination with intravenous urography, turned out to have definite pathological renal changes. Our experience has been similar.

The studies which are to be reported in this paper concern certain observations during intravenous urography to whose explanation not enough attention has been given. The observations, however, are not limited to the intravenous method, but apply even more to the retrograde method.

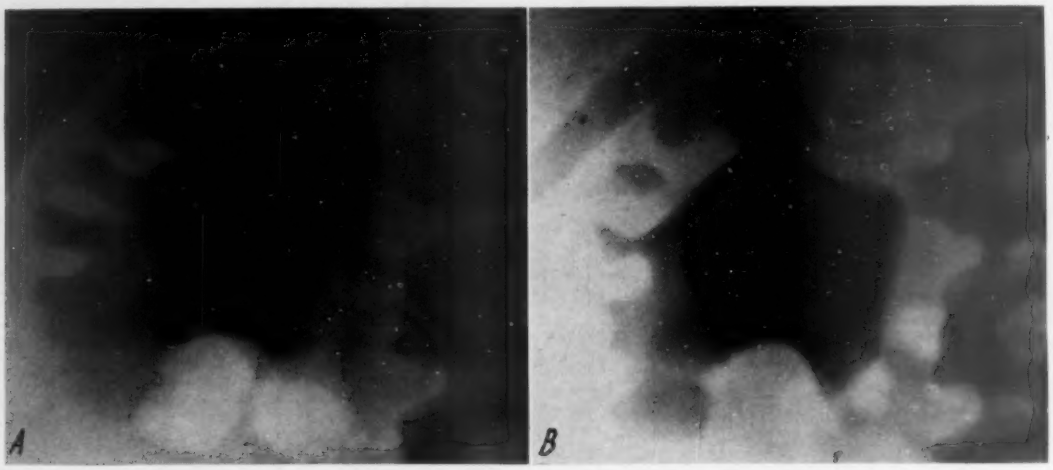


FIG. 2. *A*, pyelogram taken thirteen minutes after intravenous injection of diodrast, showing a straight medial borderline of the renal pelvis parallel to the psoas muscle. The renal pelvis is definitely dilated. *B*, pyelogram of the same renal pelvis taken forty-eight minutes after injection, showing another inner borderline medial to the first.

The first observation which seems to be of considerable interest to us concerns a pyelographic appearance of a renal pelvis, the medial borderline of which is straight and parallel to the psoas muscle. This is by no means a rare occurrence. It is more frequent in cases of hydronephrosis. We have seen it in a great many instances in patients who had more or less dilated renal pelves. A modern textbook of urological roentgenology[32] shows a reproduction of such a renal pelvis with the following legend: "Hypertrophy of the psoas muscle with a deep renal fossa in which the kidney is wedged may result in a distorted hydronephrotic pelvis." Obviously the authors have the conception that the medial straight borderline of the renal pelvis on the pyelogram actually represents the distorted anatomical borderline of this renal pelvis. There has been considerable discussion in the literature, particularly abroad, in regard to this pyelographic observation. Hutter[14,15,16] has published a number of papers on this subject, and has interpreted the finding as evidence of an atonic state of the renal pelvis. He believes that in cases with considerable stasis the renal pelvis becomes dilated and loses its tone, and therefore its shape may be changed by adjacent structures. Ribbing,[26,27] in very interesting papers, has contradicted this opinion. He believes that, at least in retrograde pyelography, stagnant urine is the cause of this phenomenon.

Our observations seem to agree with Ribbing's explanations in regard to the so-called "psoas border sign." In a number of cases of hydronephrosis, if we carried the examination on long enough, we were able to obtain a double medial borderline of the renal pelvis. Figure 2*A* represents a pyelogram taken thirteen minutes after intravenous injection of 20 cc. of diodrast, showing a straight medial borderline parallel to the psoas muscle. Figure 2*B*, taken after

more complete filling (forty-eight minutes after injection) shows another borderline, medial to the first, which conforms to the usual anatomical outline of the renal pelvis. The portion of the renal pelvis between these two medial borders is less dense than the rest. The straight first medial borderline thus continues to be visible on account of different density. This appearance can best be explained by assuming an incomplete mixture of non-contrast urine and dye-containing urine. In order to understand this more completely, we have to remember certain facts about the anatomical position of the kidney and the renal pelvis.

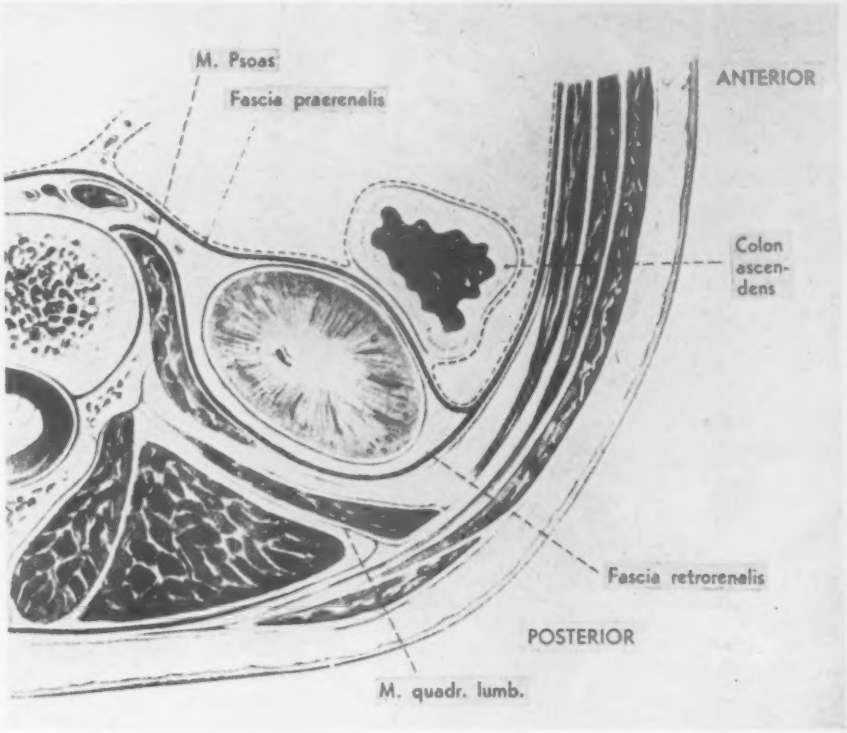


Fig. 3. Cross section of abdomen at the level of the kidney, demonstrating that the medial portion of the renal pelvis is situated more anteriorly and rests upon the psoas muscle.

From Figure 3 it is obvious that the medial portion of the renal pelvis lies anteriorly to the psoas muscle with the patient in the supine position, and represents the highest portion of the renal pelvis.

If non-contrast urine is present in the renal pelvis at the time when the dye-containing urine outlines the renal pelvis, a layer formation of both fluids occurs, the lighter non-contrast urine collecting at the highest point. Therefore the medial, i.e., higher portion of the renal pelvis contains the lighter non-contrast urine and does not become visible on the pyelogram at the beginning of the examination (Fig. 2*A*). In Figure 2*B* enough contrast dye is present to fill also this medial highest portion of the renal pelvis, at least partially, and therefore a shadow is cast outlining the true anatomical borderline of this renal pelvis. This shadow is less dense because this part of the renal pelvis does still contain a small amount of non-contrast urine.

The idea of layer formation in pyelograms is not generally known. That there may be stagnant urine present in the renal pelvis which may interfere with obtaining a good roentgenogram in retrograde py-

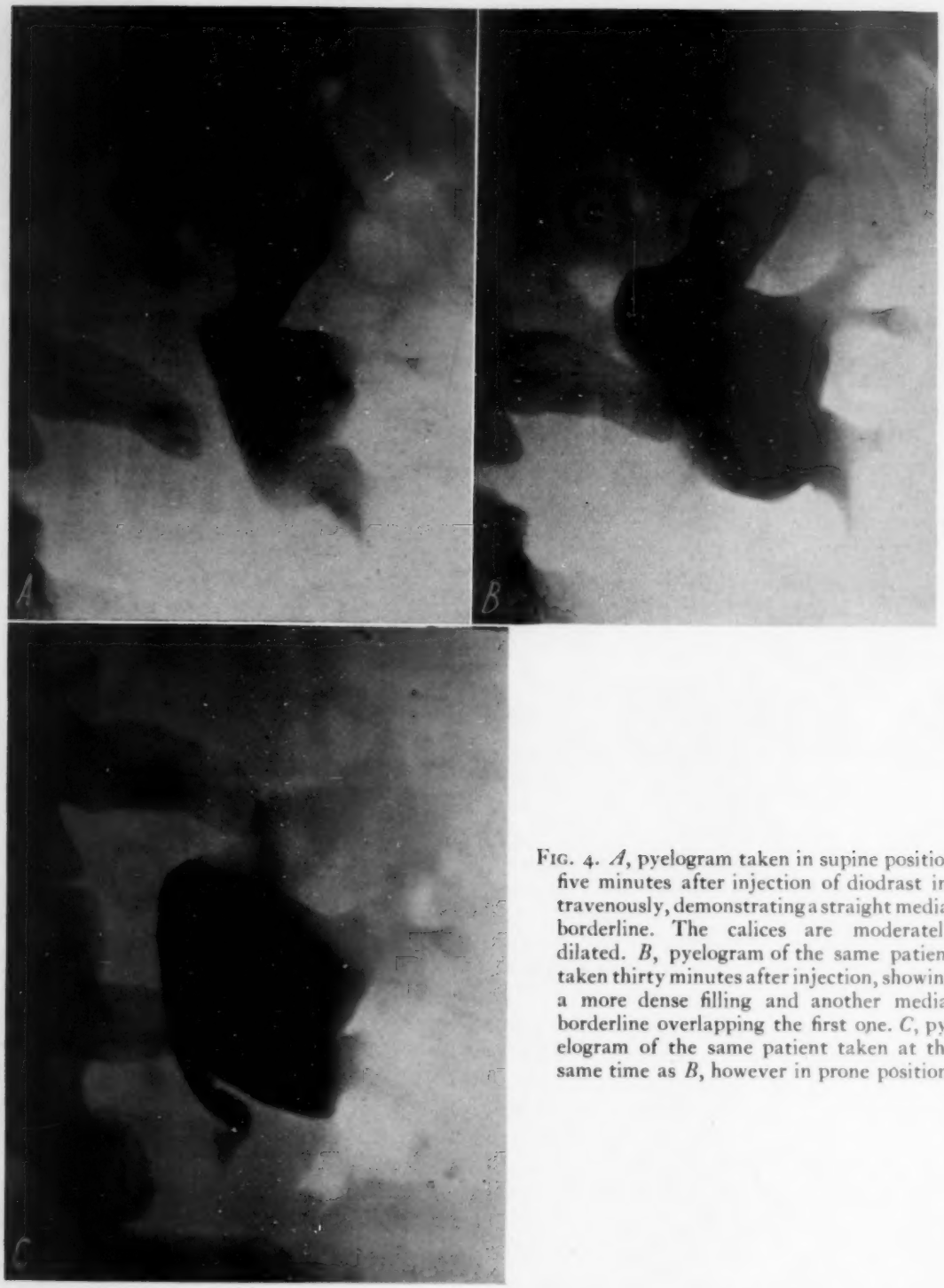


FIG. 4. *A*, pyelogram taken in supine position five minutes after injection of diodrast intravenously, demonstrating a straight medial borderline. The calices are moderately dilated. *B*, pyelogram of the same patient taken thirty minutes after injection, showing a more dense filling and another medial borderline overlapping the first one. *C*, pyelogram of the same patient taken at the same time as *B*, however in prone position.

elography is a generally accepted idea, but the assumption is that the stagnant urine mixes and dilutes the dye, thus producing a fainter shadow.[3] We have found that layer formation can be observed quite frequently in retrograde as well as intravenous urography.

In Figure 4*A* a definite "psoas border

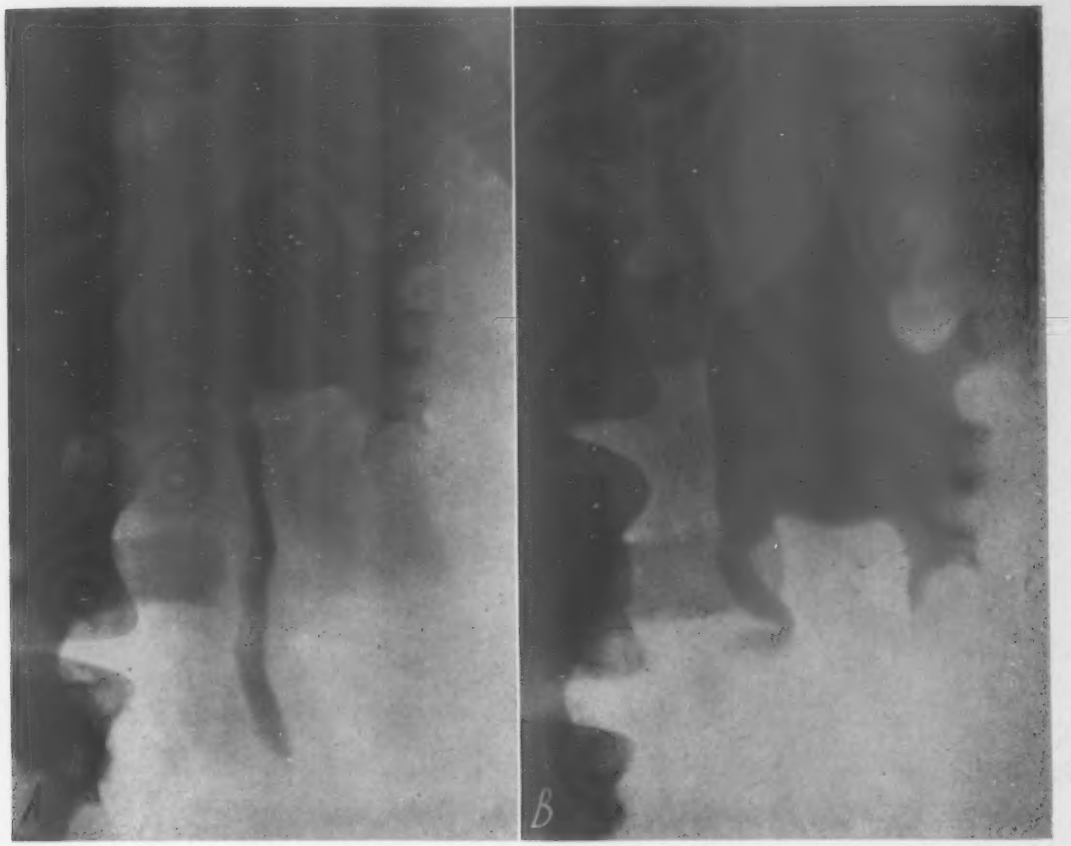


Fig. 5. *A*, pyelogram of a renal pelvis taken in supine position thirty minutes after injection, showing definite so-called "psoas border sign." *B*, same renal pelvis taken in the prone position, showing disappearance of the so-called "psoas border sign."

sign" is seen five minutes after injection of dye. In later pyelograms, taken fifteen and thirty minutes after injection, the medial borderline becomes somewhat indistinct, and the straight psoas border of the renal pelvis seems to be overlapped by another, less intense, shadow. The calices of the pelvis, particularly the upper one, appear slightly dilated (Fig. 4*B*). A pyelogram taken thirty minutes after the injection with the patient prone (Fig. 4*C*) shows very strikingly complete disappearance of the so-called "psoas border sign," and a more familiar cone-shaped outline of this portion of the renal pelvis. Simultaneously the dense fluid has drained in this position from the calices, so that only a very faint shadow of them is obtained. These pyelograms show clearly that the heavy contrast dye shifts within the renal pelvis to the most dependent portions, which naturally vary with the position of the patient.

The next pyelogram (Fig. 5*A*) illustrates that filling of the renal pelvis may appear almost complete and still a "psoas border sign" may be observed, simply because of a minute amount of non-contrast urine collecting at the highest point. It disappears as soon as the patient is put in prone position (Fig. 5*B*).

All the previous cases showed the "psoas border sign" in patients with more or less dilated renal pelves, but it can also be observed when the pelves are not obviously dilated (see Fig. 6, *A* and *B*).

An easy way to demonstrate a considerable amount of non-contrast urine in a dilated renal pelvis was furnished by the

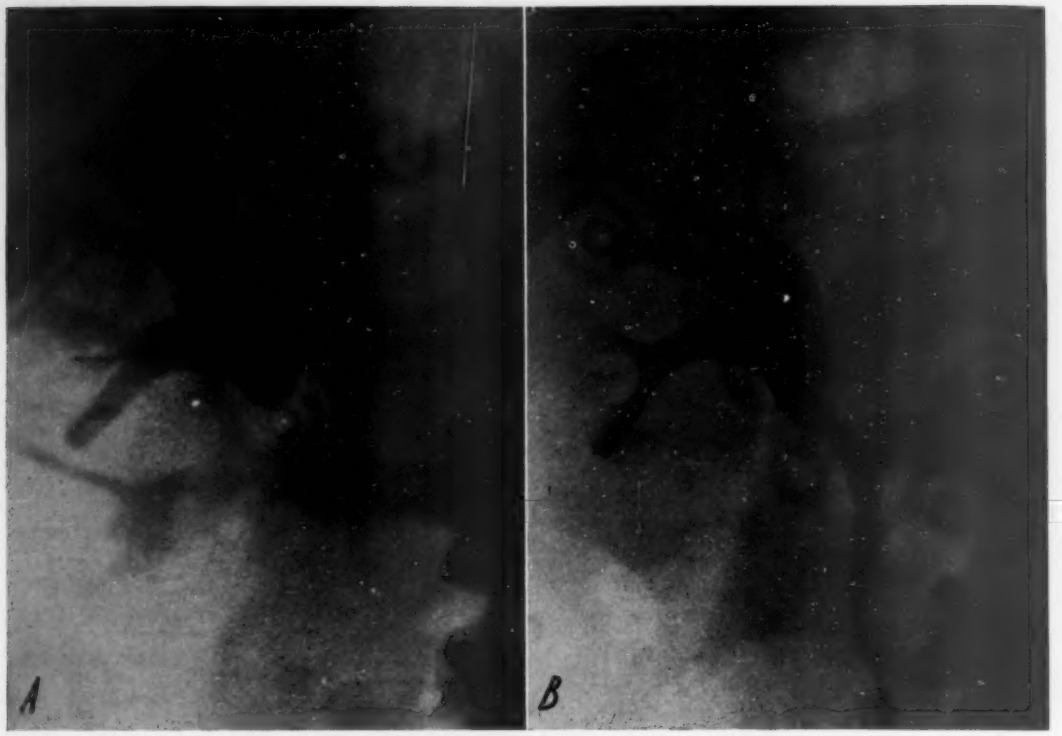


Fig. 6. *A*, pyelogram taken five minutes after injection in the supine position. *B*, same case forty minutes after injection. Note filling of the medial portion of the renal pelvis, which lies more anteriorly than the lateral portion in the supine position.

case of a young woman who had a stone at the lower end of the ureter (Fig. 7). A pyelogram taken with the patient in a lateral position, the ray directed horizontally,

Fig. 7. Pyelogram of a patient with a low ureteral stone taken twenty-five minutes after injection of dye. The patient is in a left lateral recumbent position. The rays are directed horizontally. Note almost horizontal fluid level of the dye.

demonstrated an almost straight upper borderline of the dye, the dye filling only the peripheral minor calices. The routine supine position showed in this instance a hazy outline of several clubbed calices and a dilated renal pelvis.

Aside from the phenomenon of the "psoas border sign," there are other observations in pyelographic studies which become very simple to understand if one is aware of the layer formation of contrast and non-contrast urine. For illustration, an instructive case may be mentioned in which layer formation took place in only a few of the calices of the left renal pelvis. This was a man who had for years complained of colicky pain in the left flank, occurring in attacks and radiating toward the groin. The clinical diagnosis was left renal stone. The plain roentgenogram revealed two stones in the left renal pelvis, a large one, apparently of dumbbell shape, and a smaller one. Intravenous pyelography

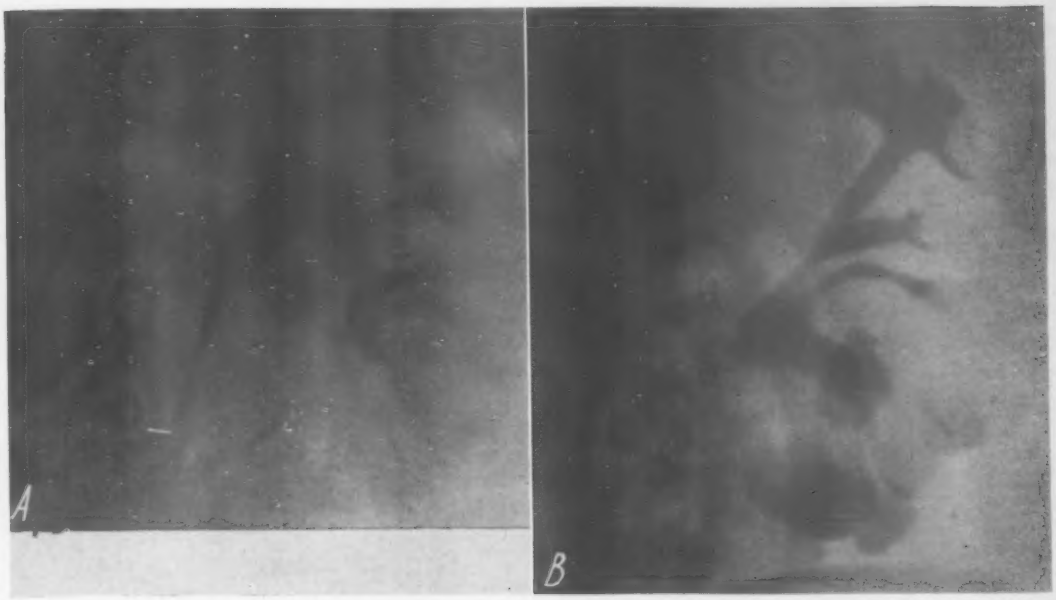


Fig. 8. *A*, normal appearing renal pelvis thirty minutes after injection. However, there is an ill-defined deposit of dye in the lower part of the renal pelvis. *B*, same patient twenty minutes later in the upright position, showing at least four dilated calices at the lower pole partially outlined by dye.

showed that the renal pelvis on the right consisted of numerous minor calices, and that there was an apparently similar renal pelvis on the left side. A pyelogram taken thirty minutes after injection showed no distortion of the left pelvis in spite of the presence of the stone (Fig. 8*A*). There was, however, a small amount of dye outside the dye-filled calices which could not be properly localized. The patient was allowed to leave the roentgen table and walk about. A pyelogram taken twenty minutes later in the upright position showed four markedly dilated renal calices outlined by a small deposit of dense dye at their lower poles, having an indistinct upper borderline, while the remaining parts of these calices were not filled with dye (Fig. 8*B*). These calices were obviously the ones which were blocked by the big renal stone previously described. They contained stagnating urine and the amount of dye which was excreted into them was too small to outline completely these markedly dilated calices in the supine position. When the patient was re-examined in the supine position for comparison with the pyelogram in the upright position, there was not, even after ninety minutes, enough dye in the dilated calices to outline them completely and clearly, but the dye then collected only at the dependent portion, giving an ill-defined deposit which would have been hard to interpret without the pyelogram in the upright position. This case illustrates that the layer formation in pyelography may influence not only the size but the contour of the contrast shadow.

Surprising as it may seem, layer formation in pyelography can be understood easily if one remembers that the specific gravity of contrast urine obtained from a patient after intravenous urography is considerably higher than the specific gravity of the same patient's urine before the intravenous injection of dye.

We were able to demonstrate layer formation experimentally, duplicating the conditions of intravenous urography in the same manner as Laurell[20] and Ribbing[26,27] had done for the conditions of retrograde urography. Ribbing also attempted this experiment, but was unsuccessful. The experiment was carried out in the following manner:

FIG. 9. *A*, layer formation of dye-containing urine and urine immediately after they were poured into the same container. *B*, the same fluids fifteen minutes later. Note that fluids have not mixed. *C*, the same fluids after stirring. Note that layer formation has disappeared.

The patient's urine was collected before intravenous injection of the dye and again collected at the end of intravenous pyelography, when the bladder contained mainly contrast urine, as visualized on the pyelogram. A paper cup was used and the contrast urine was allowed to flow slowly through a ureteral catheter into the normal urine. After the whole quantity of urine had been added, roentgenograms showed that the mixture was not uniform, and the fluids stayed separated for a considerable length of time.

Figure 9 illustrates this experiment with urine whose specific gravity was 1.027 before injection of the dye, and 1.065 at the end of the pyelography. It shows layer formation clearly, the iodine-containing urine forming the lower layer. It should be emphasized that the experiment is successful only if the dye-containing urine is added cautiously, because gross motion or any shaking of the cup containing the fluids will prevent the formation of layers. It may also be of interest to note that a very soft exposure failed to demonstrate the slight difference in densities, and that a certain hardness of exposure is necessary for the demonstration of layer formation (Fig. 10). This may possibly explain why Ribbing[26] was unable to demonstrate layer formation in his experiment with the contrast urine obtained after intravenous pyelography, while he demonstrated the layers when imitating the conditions of retrograde pyelography.

Obviously the possibility for layer formation is present wherever the specific gravity of contrast urine differs sufficiently from the specific gravity of the urine secreted before the injection. The rather low specific gravity of urine in hydronephrosis may be

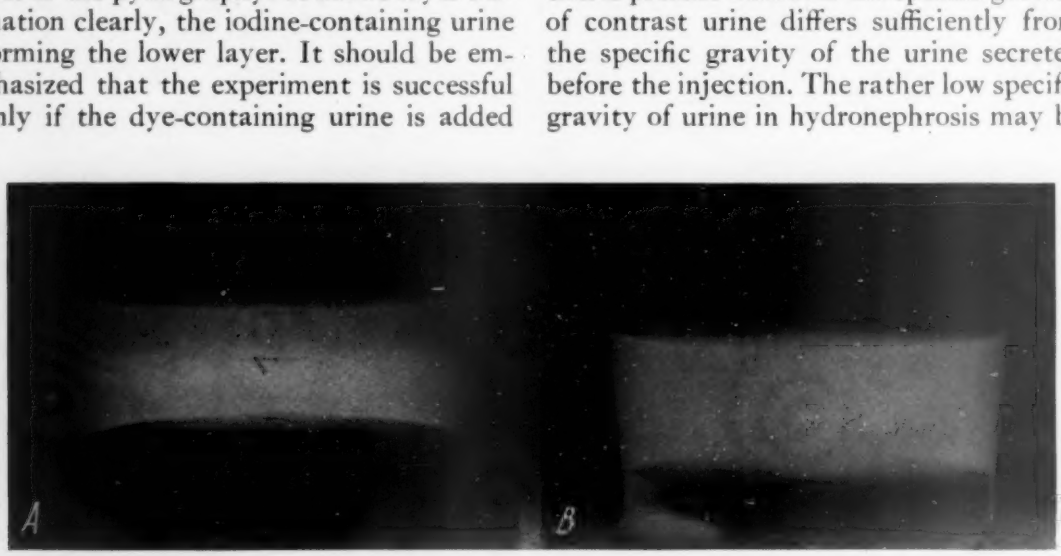


FIG. 10. *A*, layer formation in dye-containing urine and urine. Exposure values: 43 kv., 100 ma., one second. *B*, same with softer exposure: 30 kv., 100 ma., 7/8 second. Note that this soft exposure fails to make the layer formation obvious.

one of the factors leading to layer formation in this condition. However, obviously a more important factor than this is the stasis of urine in hydronephrotic renal pelves. In a normally functioning renal pelvis the residual urine is quickly eliminated by the physiological contractions of the pelvis in the first stages of excretory urography. Our observations on intravenous urography, however, lead us to believe that a small amount of residual urine may occur very readily in a normal renal pelvis.

In the literature layer formation in pyelography has been mentioned, but usually this phenomenon was thought of only when the upright position was used. Thus Hennig and Lechnir[11] recommend strongly a new method of demonstrating a hydronephrotic renal pelvis by the retrograde injection of small quantities of thorotrast. If pyelograms are then taken in the upright position, fluid levels are seen. The authors claim that the results can only be obtained with thorotrast, which, in contrast to all other dyes used, such as uroselectan, does not have the property of mixing thoroughly with the urine. Besides Ribbing, the French authors Lepoutre and Monnier[21] and Heitz-Boyer[9] have observed fluid levels in retrograde pyelography, and in hydronephrotic kidneys following intravenous pyelography, by the use of the upright position. The authors point out that it is important to be familiar with the suppression of the shadow of the upper calix in the upright position, because it contains, of course, the noncontrast urine in this position and therefore is not demonstrated in its outline on the roentgenogram. It may lead to the erroneous diagnosis of a pathological change, such as tumor defect, if one is not aware of this fact.

It should be mentioned that variations in the method of doing pyelographic studies have been recommended by various authors in order to avoid certain errors. Pyelograms in the ventral position have been recommended, or the upright position,[31] particularly for the diagnosis of ptosis, or pyeloscopy[8,13] and aimed exposures,[18] but in most instances the rationale for employing these methods has been to obtain additional projections of the renal pelvis. In the latter papers no mention has been made of the fact that layer formation within the renal pelvis is responsible for the additional information which is often obtained by varying the position of the patient. We believe from our studies that the retention of noncontrast urine and its failure to mix with the dense dye are important factors in obtaining so much additional information, if one varies the positions of the patient. We think that the use of compression and variations in position are often of value in clarifying doubtful findings, especially if one remembers the possibility of layer formation when interpreting pyelograms.

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VARIABILITY IN ONSET OF OSSIFICATION IN EPIPHYSES AND SHORT BONES OF THE EXTREMITIES*

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THREE recent studies, those of Francis[2] and Francis and Werle[3] and of Flecker,[1] have added much to our knowledge of the age when bone begins to appear in those cartilaginous areas which are to be replaced entirely by bone after birth. Flecker's paper was published last, and contains an extensive review of the pertinent medical and anatomical findings. He compares his work on time of ossification and fusion in epiphyses throughout the body with the findings on record. The papers of Francis and Werle are covered in his review so that further reviewing at this point seems superfluous.

Flecker had hoped to collect all previous publications and include them with his own work in formulating a distribution scale for time of ossification for each center. He found that he could not do this because few of the investigators described their population samplings clearly or told how many children were included in their studies. Many made statements about time of appearance but failed to say how they had arrived at these figures. Francis and Werle described their group and gave the number of cases included, but confused the issue further by suggesting that only the 80th percentile of the group should be used to calculate the mean age for onset of ossification in each epiphysis. Flecker concludes by stating that in spite of the extensive studies published on time of ossification, one still has difficulty in finding a statement about the average time of appearance in terms which are clear enough to decide what the limits of normality are.

Prior to the publication of Flecker's paper we had encountered the same difficulty and we agree with his criticisms. We found, too, that there is one idea which is common to all studies of ossification time with which we are familiar, which confuses the issue as much as any idea which Flecker criticized. This is the universal practice of assessing onset of ossification in terms of the date when the roentgenogram is taken. Francis and Werle calculated their tables for age of appearance from the ages when they saw the bone center for the first time on a roentgenogram. Their roentgenograms were taken at three or six month intervals. Therefore an epiphysis which began to calcify at about four months was assigned the skeletal age of six months, since that was the first roentgenogram in which it was seen. All investigators, including Flecker, have followed the same procedure. When one is setting up a standard, a large error is introduced by this practice unless every child included in the study has had an extensive series of roentgenograms taken at closely spaced intervals. We have therefore estimated from serial reontgenograms on each child the *actual* time when each cartilaginous center began to be replaced by bone. We have found it easier to assess the time of appearance of a center than it is to judge the time of appearance of later maturational features, although the latter has been done successfully by Flory[4] and Todd.[5] After spreading each child's series out and assigning epiphyseal bone age according to the preceding rate of development, size and form of the new bone center, we calculated the means given in Tables I and II from the data. Sixty-one centers were assessed. The epiphyseal centers for the middle third, fourth, fifth and the distal fifth phalanges of the toes were omitted because they tend to bud directly off the primary center or are never formed. The norms presented here are means, not 80th

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TABLE I

TIME AND ORDER OF ONSET OF OSSIFICATION
(boys)

Order of Appearance	No. of Boys	Mean Age in Months	Standard Deviation (months)	Coefficient of Variability (per cent) $100 \times \frac{SD}{M}$
1 Distal femur	50	0	0.1	
2 Proximal tibia	50	0.1	0.3	
3 Cuboid	50	0.5	0.7	
4 Head of humerus	50	0.7	0.8	
*5 Capitate	50	2.4	1.8	±73.1
*6 Hamate	50	3.4	2.2	67.2
7 Distal tibia	50	3.9	1.5	37.5
8 Head of femur	50	4.4	2.0	45.9
*9 Lateral cuneiform	50	4.4	4.3	97.8
*10 Capitulum	50	6.3	4.3	68.3
*11 Gt. tuber. humerus	50	11.4	7.2	63.3
12 Distal fibula	50	12.5	4.1	33.0
13 Distal radius	50	13.0	4.7	36.2
14 Prox. 3rd finger	50	16.2	5.3	33.0
15 Distal 1st toe	50	16.8	5.6	33.5
16 Prox. 2nd finger	50	17.3	5.0	28.9
17 Prox. 4th finger	50	17.7	5.4	30.8
18 Metacarpal II	50	17.9	5.1	28.3
19 Distal 1st finger	50	18.4	6.2	33.9
20 Prox. 3rd toe	50	19.5	5.2	26.5
21 Prox. 4th toe	50	21.0	5.1	24.3
22 Metacarpal III	50	21.1	6.4	30.2
*23 Medial cuneiform	50	21.9	9.9	45.1
24 Prox. 5th finger	50	22.2	5.6	25.4
25 Prox. 2nd toe	50	22.2	5.8	26.2
26 Metacarpal IV	50	23.6	7.1	29.9
27 Middle 3rd finger	50	24.9	7.6	30.6
28 Middle 4th finger	50	24.9	7.8	31.2
29 Metacarpal V	50	26.0	8.0	30.5
30 Middle 2nd finger	50	26.9	7.5	27.8
*31 Triquetral	50	27.3	15.9	58.4
32 Metatarsal I	50	27.7	4.7	17.1
33 Distal 3rd finger	50	27.8	6.4	23.2
34 Distal 4th finger	50	28.3	7.0	24.7
*35 Middle cuneiform	50	28.4	11.2	39.4
36 Metacarpal I	50	29.8	7.3	24.4
37 Prox. 1st toe	50	29.9	5.8	19.3
38 Prox. 5th toe	50	32.0	5.9	18.4
*39 Navicular (foot)	50	33.4	13.5	40.3
40 Metatarsal II	50	33.4	6.8	20.4
41 Prox. 1st finger	50	34.8	7.9	22.6
42 Distal 2nd finger	48	37.0	7.9	21.4
43 Distal 5th finger	48	37.4	7.4	19.7
44 Middle 5th finger	48	40.3	11.7	29.0
45 Metatarsal III	47	41.5	7.9	19.0
46 Gt. troch. femur	48	42.6	7.6	17.9
*47 Lunate	48	46.0	19.3	42.3
48 Proximal fibula	46	47.0	11.8	25.2
49 Metatarsal IV	46	48.7	9.0	18.5
50 Distal 4th toe	44	51.2	10.1	19.8
51 Patella	36	51.9	11.6	22.4
52 Distal 3rd toe	44	53.5	11.2	20.9
53 Metatarsal V	45	53.6	10.6	19.7
54 Distal 2nd toe	41	57.0	11.4	20.0
55 Navicular hand	38	60.1	14.1	23.4
*56 Proximal radius	37	63.5	17.2	27.1
*57 Greater multangular	39	64.3	19.7	30.7
58 Lesser multangular	36	64.4	15.2	23.6
59 Med. ep. humerus	37	73.6	17.5	23.8
60 Distal ulna	31	82.4	10.6	12.9
61 Epiph. calcaneus	31	89.6	14.0	15.6

TABLE II

TIME AND ORDER OF ONSET OF OSSIFICATION
(girls)

Order of Appearance	No. of Girls	Mean Age in Months	Standard Deviation (months)	Coefficient of Variability (per cent) $100 \times \frac{SD}{M}$
1 Distal femur	50	0		
2 Proximal tibia	50	0.1		
3 Cuboid	50	0.4		
4 Head of humerus	50	0.9		
*5 Capitate	50	2.3	2.1	92.1
*6 Hamate	50	2.5	2.3	91.7
7 Distal tibia	50	3.4	1.4	41.2
8 Head of femur	50	3.7	1.6	44.1
*9 Lateral cuneiform	50	3.8	4.4	113.6
*10 Capitulum	50	4.1	3.6	87.5
11 Gt. tuber. humerus	50	6.6	3.3	49.4
12 Distal fibula	50	9.3	2.6	28.5
13 Prox. 3rd finger	50	10.4	3.1	29.7
14 Distal 1st toe	50	10.6	2.8	26.5
*15 Distal radius	50	10.8	4.4	41.1
16 Proximal 2nd finger	50	11.0	3.0	27.4
17 Proximal 4th finger	50	11.1	3.2	29.1
18 Proximal 3rd toe	50	12.2	3.8	30.8
19 Distal 1st finger	50	12.8	5.0	38.9
20 Metacarpal II	50	12.8	3.7	29.0
21 Proximal 4th toe	50	13.6	3.8	28.0
22 Proximal 2nd toe	50	14.1	3.8	27.2
23 Metacarpal III	50	14.2	4.0	28.4
24 Proximal 5th finger	50	15.2	4.2	27.5
25 Middle 4th finger	50	15.8	4.8	30.2
26 Middle 3rd finger	50	15.9	4.9	30.8
27 Metacarpal IV	50	16.0	4.1	25.9
*28 Medial cuneiform	50	16.7	8.5	50.7
29 Metacarpal V	50	17.2	4.7	27.4
30 Middle 2nd finger	50	17.3	5.2	30.0
31 Distal 4th finger	50	19.9	5.9	29.8
32 Metatarsal I	50	20.1	3.3	16.6
33 Distal 3rd finger	50	20.2	3.9	19.4
34 Metacarpal I	50	20.3	5.3	26.0
35 Proximal 1st toe	50	20.3	5.5	27.1
*36 Middle cuneiform	50	21.3	7.6	35.8
37 Proximal 5th toe	50	21.3	4.8	22.4
38 Proximal 1st finger	50	21.6	5.1	23.8
*39 Triquetral	50	23.6	13.7	57.9
40 Middle 5th finger	50	24.9	7.9	31.7
41 Distal 5th finger	50	25.5	7.0	27.6
*42 Navicular (foot)	50	25.8	11.1	43.3
43 Metatarsal II	50	25.8	6.1	23.6
44 Distal 2nd finger	50	25.8	6.9	26.9
45 Metatarsal III	50	29.1	6.4	21.9
46 Gt. troch. femur	50	29.8	6.4	21.5
47 Distal 4th toe	50	30.7	7.9	25.9
48 Proximal fibula	50	32.6	9.3	28.5
49 Distal 3rd toe	50	32.8	7.7	23.6
50 Metatarsal IV	50	34.0	7.2	21.2
*51 Lunate	50	34.6	14.2	41.1
52 Patella	43	34.8	8.5	24.6
53 Distal 2nd toe	50	35.5	7.3	20.5
54 Metatarsal V	50	38.6	8.4	21.7
55 Med. ep. humerus	47	41.3	9.9	24.1
*56 Greater multangular	46	47.0	14.8	31.5
57 Proximal radius	46	47.5	12.1	25.4
58 Navicular hand	45	47.8	12.3	25.7
*59 Lesser multangular	44	48.3	14.8	30.6
60 Distal ulna	42	63.2	15.3	24.3
61 Epiph. calcaneus	42	63.7	11.8	18.4

percentiles such as have sometimes been used by other investigators[3] in constructing norms for ossification.

We have not found evidence that illnesses common to this age level have a specific delaying action on all centers which are due to calcify just at the time when the illness occurs. Our means and deviations are being used to test this point further.

CHILDREN INCLUDED IN THE GROUP

Sixty-four boys and 69 girls were included. They are all white, are American born, and are selected from the Fels Research Institute children solely on the basis of the completeness of their roentgen series. They tend, as a group, to be better than average in health, mental development and social and economic endowment. They do not, however, represent any one economic class and are not to be regarded as representing only a privileged group.

We restricted the number of assessments for an epiphysis to 50 for each sex in order not to weight the earlier appearing centers unduly, since some of the children are too young to have acquired all 61 ossification centers. No child was used just once.

The *order* of ossification is much the same for the average as for the 80th percentile, or 20th percentile, with a few significant exceptions. It has long been suggested that the irregular bones of the hand and foot appear in atypical order in relation to other centers when growth is either markedly accelerated or greatly retarded. The degree of variability in time of appearance of each center is expressed in Tables I and II in terms of standard deviation and coefficient of variability, the latter being a function of standard deviation and mean (coefficient of variability = $100 \times SD/M$). Within ± 1 standard deviation from the mean age in months for any center, approximately 68 per cent of the children will have acquired an ossification center. Therefore if calcification begins in an epiphysis more than 1 S.D. early or late the center must be considered as falling in the most advanced or most retarded 16 per cent of our group as the case may be, as regards the actual age for onset of ossification for that epiphysis. It is obvious that those centers due to appear at four years may vary more in actual months (and therefore have a larger standard deviation) than those due at four months, but the percentage variation is less. For example, the head of the femur in boys, due at 4.4 months is much delayed (nearly 50 per cent) if that is not seen by 6.4 months while the fourth metatarsal due at 48.7 months is only about 4 per cent late if delayed two months. Therefore, coefficients of variation tend to decrease as one follows down the list of centers from the earlier appearing centers to the late ones. The tendency to greater variability in onset of ossification of carpal and tarsal bone centers as contrasted with epiphyses of long bones is shown by their greater coefficients of variability and greater standard deviation as compared with other centers due to appear at comparable ages. We have starred these centers in Tables I and II. The capitate and hamate in boys have coefficients of variability of 73 per cent and 67 per cent respectively as compared with 38 per cent and 46 per cent for distal tibia and head of femur. Similarly at a later age level triquetral has a coefficient of variability of 58 per cent compared with 28 per cent and 17 per cent for middle second finger and the first metatarsal appearing at about the same ages.

SUMMARY

Tables of time of ossification, including means, standard deviations and coefficients of variability, are calculated by interpolation for sixty-one centers. The material used for the compilation of these data consisted of serial roentgenograms of all extremities of the left side, on 64 white boys and 69 white girls, many of whom have been roentgenographed from birth to the age of nine years. Standard deviations and coefficients of variability are presented. Carpal and tarsal bones are definitely more variable in time of appearance than are true epiphyses. Nevertheless, there is no

marked difference in *order* of ossification in advanced or retarded children or those growing at an average rate. The sex differences in order of ossification given in Tables I and II seem to us to be largely artifacts of sampling. We have not been able to find adequate evidence of the specific delaying action on certain centers, of illness occurring just previous to calcification of these centers.

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RADIATION TREATMENT OF LYMPHANGIOMA*

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LYMPHANGIOMA is a rather uncommon tumor which is relatively easy to diagnose but extremely difficult to treat. It is usually seen in children or young adults, and frequently causes disfiguring deformities which are a source of great anxiety to the parents and to the patients. The physician called to treat such a patient is confronted with a most difficult problem. Any of the procedures advised at the present time may result in unsightly scars, and those which require repeated punctures of, or injections into, the tumor may cause an infection which is sometimes fatal. The radiologist not infrequently attempts the treatment of these tumors without fully realizing the seriousness of the problem. The fact that lymphangioma resembles hemangioma, a tumor known to respond well to irradiation, and that the name suggests a radiosensitive tumor, may lead him to make a much too favorable prognosis, or to attempt the treatment of the patient without consultation or consideration of other methods of treatment. When, as so frequently happens, the results are unsatisfactory he may find that both his judgment and his treatment are discredited.

The unsatisfactory results obtained with irradiation of these tumors at this hospital has led us to review the literature regarding the treatment of lymphangioma and to report the result of irradiation in 12 treated cases.

CLASSIFICATION

In general, the term lymphangioma includes a considerable variety of slow growing, usually congenital tumors occurring in skin, subcutaneous and deep areolar tissues; but occasionally invading the muscles of neck, tongue, lip and other structures. Single or multiple lesions occur. Histologically they are composed of dilated lymph vessels, the walls of which are formed of endothelial cells and fibrous tissues. Three distinct forms have been described.

Lymphangioma simplex occurs chiefly in the skin, and is composed of an anastomosing network of vessels or spaces of small or medium caliber. They may or may not show evidence of cell proliferation.

Lymphangioma cavernosum consists of a system of closed lymph spaces lined with endothelium, and containing fluid or coagulated lymph.

Lymphangioma cysticum consists of a collection of cysts of varying size, lined with flat endothelium and containing lymph.

Of the three forms, the cavernous is the most common. Some pathologists and most clinicians describe two additional forms—the *verrucous*, which is composed of new, imperfectly formed lymph vessels, and is a true tumor; and the *cystic hygroma*, a form which usually arises in the neck extending upward toward the parotid and ear, and downward to the supraclavicular fossa and even into the mediastinum.

REVIEW OF LITERATURE

In 1927, Andren[1] reported the results of radium and roentgen irradiation in 11 cases of lymphangioma all of which were cavernous and subcutaneous; no biopsies were taken. Of the 7 cases treated with radium, 5 were children; their condition was unchanged. One adult was cosmetically restored although an inflammatory reaction of the second degree was produced by the treatment; 1 showed improvement. Four cases were treated by roentgen irradiation, given in repeated series, using 0.5 mm. copper filtration. Only 1 of these improved under treatment. Of the entire group, 7 cases (64 per cent) were unchanged. Andren concluded that (1) the radiation must be strongly filtered; and (2) the risk of sec-

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ondary atrophic changes occurring after treatment must be borne in mind.

Figi,[5] of the Mayo Clinic, reported in 1929 the treatment with radium of 13 cases of multilocular lymph cysts of the neck. The dosage used was 3,000–7,000 mg-hr. at 2.5 cm. distance and 2 mm. lead screening, which was repeated every two to three months up to as many as nine treatments. Three of the 13 cases were entirely well at the time the report was made, 2 had regressed, 1 showed no change, and 7 died of acute infection of the tumor while treatment was being carried out. (It should be noted, however, that 4 of the last group were infected before treatment was begun.)

Andrews[2] in 1938 had treated 8 cases of lymphangioma circumscripta, but none of the cavernous type. In 1940, he[3] supplemented his earlier report with the conclusion that these tumors did not respond favorably to radium treatment, although exceptions to the rule were possible.

An extensive study of the treatment of 41 cases of lymphangioma at the Memorial Hospital, New York, was reported in 1940 by Watson and McCarthy.[8] In general, they advocate surgery followed routinely by irradiation in order to control recurrence and prevent keloid formation. If removal of the tumor was incomplete radon seeds might be planted in the remaining portion. Seventy-seven per cent of the cases so treated improved; in 4, the tumor recurred and required a second operation. Eighteen cases were treated by irradiation alone and all developed marked skin damage. In 35 per cent the results were good; in 25 per cent, poor. These authors considered cystic hygromas of the neck as a separate group, in which, up to 1929, they had had a mortality of 54 per cent with radium treatment. Later their results were more satisfactory with the injection of sodium morrhuate before irradiation. If this treatment failed surgery was resorted to; if surgery was incomplete irradiation was given in some instances.

Stewart and Farrow[7] in a discussion of the radiosensitivity of tumors acknowledge that lymphangiomas are more resistant than the hemangiomas, and that while the superficial small lesions of the extremities show a certain sensitivity, the deep lesions are definitely resistant. They do not encourage radiation treatment of cystic hygromas.

Cutler, Buschke and Cantril[4] believed that treatment of cystic hygromas should be limited to careful surgical excision.

MacKee[6] in 1938 reported 3 cases which had been treated without resultant change in the tumor.

REVIEW OF CASES

We have examined the records of 12 cases treated with roentgen rays or radium at this hospital during the years 1930 to 1940 (Table 1), after which time radiation treatment was replaced by surgery as a general procedure. In 2 cases only was the diagnosis confirmed by biopsy. Histopathological classification is therefore impossible, but the clinical diagnosis is probably correct in a high percentage of the group. The use of the biopsy as a means of diagnosing lymphangioma probably should be discouraged since the findings are often inconclusive and because fatalities not infrequently follow infections.

Three patients had one treatment only, and were not seen again in the clinic. They are not included in Table 1. Of the group of 12 cases, 7 showed no benefit from the treatment, and 4 showed a partial disappearance of the lesion. However, the dose required to produce this result also caused some permanent damage to normal tissues. One case in which the lesion was of the verrucous type showed a satisfactory response although the dose given was well below that likely to cause injury to normal tissue.

CONCLUSIONS

The results of this review seem to be quite definite. There is only one form of lymphangioma, the verrucous type of lymphangioma simplex, which responds

TABLE I

PATIENTS TREATED WITH ROENTGEN OR RADIUM IRRADIATION FOR LYMPHANGIOMA AT THE MASSACHUSETTS GENERAL HOSPITAL 1930–1940

Case No.	Biopsy	Roentgen or Radium Treatment	Surgery and Roentgen Treatment	Improved	Unimproved	Results
13737	0	1	0	1		Small skin lesions; given ulcer dose treatment
13521	0	1	0		1	No improvement
10962	0	1	0		1	No improvement
U223990	1	1	0	1		Verrucous type; much improved
10068	0	1	0		1	No improvement
9104	1		1		1	Lymphangioma of orbit. Radium, no effect; good surgical result
9528	0	1	0	1		Radium result fair
85605	1		1		1	Roentgen treatment failure; surgical result fair
U44964	1	1	1		1	Cheek and orbit. Roentgen treatment failure
9092	0	1	0	1		Some improvement under prolonged roentgen and radium treatment
U230896	0	1	0	1		Roentgen and radium treatment; skin damage
13598	1	1	0		1	No improvement
Total cases 12	5	10	3	5	7	

favorably to irradiation when given in doses which do not cause permanent injury to normal tissue. All other forms either do not respond at all or require a dose larger than can be given with safety.

Infection is a real hazard in the treatment of these cases, particularly in the large tumors of the neck. For this reason the taking of biopsies and the insertion into the tumor of radium in the form of seeds or needles should be discouraged.

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NEW TYPE OF RADIUM LOADING PROTECTIVE DEVICE

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INTRODUCTION

A RECENT survey of the radiation protection in forty-five hospitals in a total of twenty-four states by Cowie and Scheele[1] has revealed some startling facts. Fourteen of the hospitals included in the survey were without a radium loading protective device. In ten others the loading device was constructed of lead less than 2 inches thick, several of these being only 1/16 or 1/8 inch thick. Special instruments for the handling of radium were lacking or inadequate in twenty-five institutions. Radium storage safes were borderline or inadequate in twenty-nine instances. In the majority of the hospitals the radium was transported to and from the radiological department in inadequate or makeshift carriers.

A number of factors are responsible for the aforementioned defects: (1) a failure on the part of the radiologists to appreciate the relative high degree of exposure in roentgens an individual may sustain to the body and hands in the careless handling of radium; (2) most long handled instruments are cumbersome and time consuming in operation and therefore are not used; (3) the cost of adequate equipment in many instances has been a deterring factor.

It is the purpose of this paper to describe a new type of radium protective device and accessory instruments for the loading and unloading of radium applicators. This equipment and the technique to be discussed, we believe, will overcome the criticisms we have enumerated. The equipment is simple in construction, easy to operate, and enables speedy preparations of radium applicators. At all times there is a lead screen interposed between the radium and the operator's body and hands. The actual exposure in roentgens to the body, hands, and finger tips is extremely small and far below that of any previously published data.

[1] Cowie, D. B., and Scheele, L. A. Survey of radiation protection in hospitals. J. Nat. Cancer Inst., 1941, 1, 767–787.

A COMPARISON OF EXPOSURE BETWEEN OLD TYPE RADIUM LOADING PROTECTIVE DEVICE AND NEW TYPE DEVICE

A study of Chart 1 clearly demonstrates the difference in the exposure factor in roentgens between the new and the old type of protective device used at the Department of Radiology, University of Rochester School of Medicine and Dentistry, and the Strong Memorial Hospital, Rochester, New York. The exposure in roentgens shown in Chart 1A represents the exposure sustained while *loading* the T-tube and colpostat. The time consumed in the process of loading is an estimate. In Chart 1B the exposure in

A MEASUREMENTS MADE WITH OLD RADIUM "ELL"				
TYPE OF APPLICATOR	AMOUNT OF RADIUM	TIME FOR LOADING	EXPOSURE TO BODY IN LOADING	EXPOSURE TO HANDS IN LOADING
T-TUBE AND COLPOSTAT	110 MG.	15 MINUTES (ESTIMATE)	0.05 r	0.55 r

B MEASUREMENTS MADE WITH NEW RADIUM "ELL"				
TYPE OF APPLICATOR	AMOUNT OF RADIUM	TIME FOR LOADING AND UNLOADING	EXPOSURE TO BODY IN LOADING AND UNLOADING	EXPOSURE TO HANDS IN LOADING AND UNLOADING
T-TUBE AND COLPOSTAT	75 MG.	5.5 MINUTES (MEASURED)	0.001 r	0.008 r

CHART I

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BODY AND FINGER EXPOSURES IN SELECTED CASES DURING ASSEMBLY OF RADIUM TANDEMS FOR INTRA-UTERINE INSERTION.

CASE	APPLICATOR MATERIAL	RADIUM		L-BLOCK THICKNESS	FORCEPS LENGTH	ELAPSED TIME	EXPOSURE IN r	
		IN APPLICATOR	OTHER in TABLE				BODY	FINGERS
		MG.	MG.	IN.	IN.	MIN.		
A	RUBBER	85	275	2	10	31	0.02	25
B	SILVER	90	10	¾	8	12	.04	.4
C	RUBBER	75	NONE	NONE	10	10	.06	1.8
D	DO	75	125	NONE	4	20	.08	36

CHART II

roentgens represents that sustained for *both* the *loading* and *unloading* of the respective applicators. The entire process was timed with a stop watch. While there was approximately only 1.5 times as much radium used with the old device as with the new device (110 mg. and 75 mg., respectively), yet there was 50 to 70 times the exposure using the old device as compared with the new device. The exposures shown in Chart IB are especially significant when contrasted with those obtained by Cowie and Scheele from representative measurements in their survey (Chart II).[2]

Our old type of protective device had no sides, and the back and bottom were constructed of 1 inch of lead (Fig. 1). The absence of lead sides permitted a direct exposure of the hands and fingers from the radium in the protective device. The temptation to work with short handled instruments was great and practically impossible to prevent with inexperienced workers.

The safety factor of 50 to 70 times over the old type of protective device has been made possible by the construction of a device which is (1) completely surrounded by lead except in front (the open side opposite the body, Fig. 3); (2) the back and bottom have been increased from 1 inch to 2 inches of lead; (3) the radium and the loaded applicators are manipulated by remote control; (4) the design of the new device and accessory instruments makes it possible to greatly shorten the time necessary to load and unload the radium applicators.

[2] By courtesy of Cowie and Scheele and the *Journal of the National Cancer Institute*.

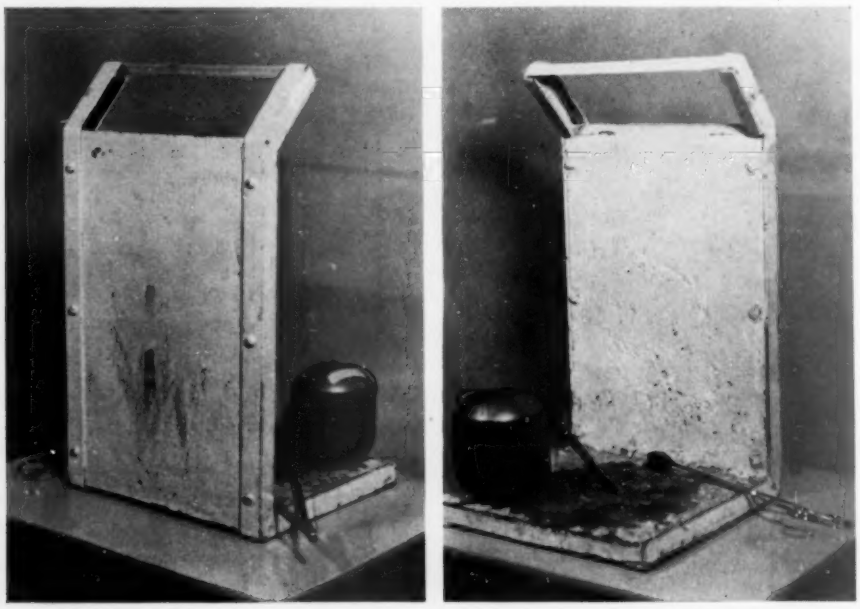

FIG. 1. Back and front views of old radium loading protective device. Note lack of lead side walls. The back and bottom are composed of lead 1 inch thick. There is no plywood covering for back of device.

GENERAL DESCRIPTION OF NEW RADIUM PROTECTIVE DEVICE

The old type of protective device (Fig. 1) should be contrasted with the new device (Fig. 2 and 3). The top, back, and bottom of the latter consist of lead 2 inches thick, and the side walls of lead 1 inch thick. On the left hand side of the bottom is a vise with a universal joint, the remote control handle of which passes through the left side wall of the contrivance. The hole in the lead wall is just sufficient in size to permit the passage of a small solid brass shaft. There is a 1 1/2 inch thick lead collar (Fig. 3, *f*) which fits over the remote control shaft just inside the left wall of the device to block any radiation which may pass through the hole in the wall. A similar hole is in the right side wall on a level with the jaws of the vise, for the introduction of the long handled radium instruments. Each instrument operated through this hole is constructed of a small solid brass rod 12.8 inches in length (Fig. 4), one end (head end) of which is drilled out to accommodate the various sections of the radium applicators. Near the handle it has a 1 1/2 inch lead collar fixed to the shaft to block the emission of radium rays which may pass through the hole in the right side of the device.

Fig. 2. New radium loading protective device, back and side views.

Fig. 3. Front view of new radium loading protective device showing radium being placed into cross arm of T-tube. *a*, long handled radium instrument; *b*, long handled curved forceps; *c*, radium being placed into cross arm of T-tube; *d*, intra-uterine portion of T-tube; *e*, radium well; *f*, lead collar on remote control shaft of vise; *g*, handle for opening and closing vise; *h*, 1 inch lead side wall.

DISCUSSION OF TECHNIQUE USED WITH NEW DEVICE

Before any radium is placed in the well (lead box or block) of the loading device, the first section of the applicator is placed horizontally between the jaws of the vise and held firmly in place by turning the remote control handle at the left side of the device which adjusts the jaws of the vise. The next section of the applicator is then fitted into the hollow or head end of the long handled radium instrument. The head end is then passed through the hole in the

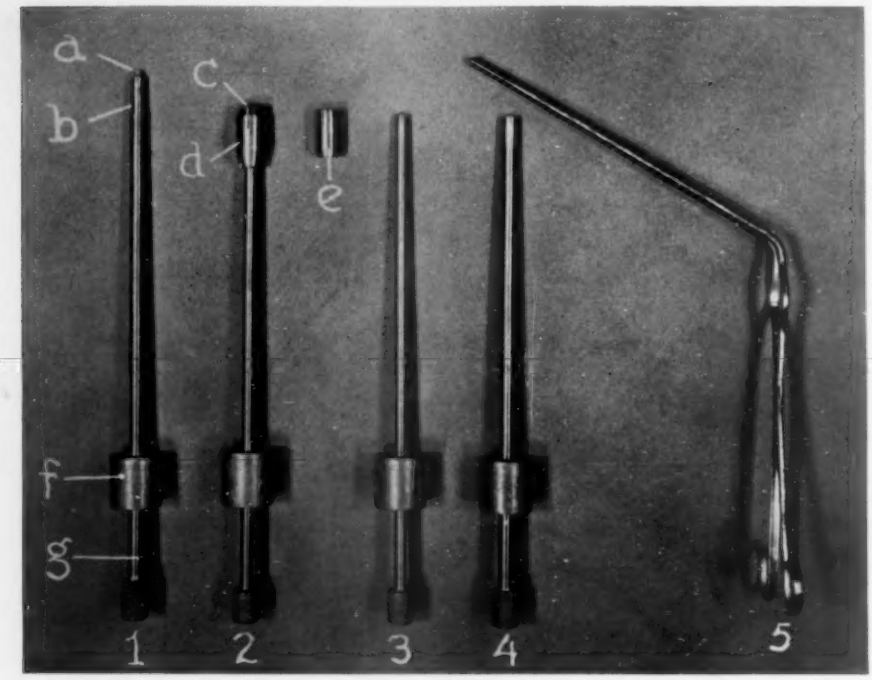

FIG. 4. Accessory instruments for handling radium. *1*, *2*, *3*, and *4* are long handled instruments with a hollow head for the reception of the various sized portions of T-tube and colpostat; *5* is long handled curved radium forceps. *a*, threaded end of section of applicator; *b*, section of applicator in head of instrument; *c*, cap to colpostat in head of instrument; *d*, removable head; *e*, small sized head; *f*, 1½ inch lead collar on shaft near handle of instrument; *g*, handle of instrument.

FIG. 5. Cap to cross arm of T-tube is being screwed in place. *a*, handle of long handled radium instrument; *b*, lead collar on shaft of instrument; *c*, shaft of long handled instrument; *d*, assembled sections of intra-uterine portion of T-tube; *e*, radium well; *f*, lead collar on remote control shaft of vise; *g*, handle for opening and closing vise; *h*, lead side wall.

right side of the block. The well containing the required amount of radium is then placed in the device, and by means of a long handled forceps curved at almost a right angle (Fig. 3 and 4) the radium is placed into the first section of the applicator, which is then screwed into place (Fig. 5). The joint of the forceps should be a box joint to insure stability and proper approximation of the tines at the tip. The radium loading instrument is withdrawn from the device, another section placed in the hollow end, and the process repeated until the entire multisectional applicator is loaded and assembled. If the applicator happens to be a straight lead tube a little different technique is necessary. The tube of required length is

made and the base secured in the vise in a vertical position. By using the long handled, curved forceps, the radium is introduced until the applicator is loaded.

At no time are the hands and fingers directly exposed to the radium. The hands are at all times at least 12.8 inches away from the radium. To touch the latter with the fingers would have to be a deliberate and very awkward act.

The ease of manipulation of the new equipment with practice has reduced the time of loading by one-third to one-fifth over that with the older technique. This has resulted in a marked reduction in actual exposure. In addition there is the added protection afforded by the lead sides and the necessarily increased working distance of the hands from the radium.

TESTS SHOWING EXPOSURE IN ROENTGENS WITH VARIOUS APPLICATORS AND AMOUNTS OF RADIUM

Chart III shows the measurements obtained while loading and unloading four different types of radium applicators. The

TYPE OF APPLICATOR	AMOUNT OF RADIUM PER APPLICATOR	TIME IN MINUTES REQUIRED TO LOAD / UNLOAD APPLICATOR.	EXPOSURE IN r TO THE INDIVIDUAL WHILE LOADING AND UNLOADING APPLICATORS FOR A SINGLE PATIENT.		
			BODY	FOREARM	FINGER TIPS
T-TUBE (CARCINOMA OF CERVIX)	55 MG.	6 MIN.	0.003	0.005	0.02
COLPOSTAT (VAGINAL FORNICES)	20 MG.	2 MIN.	0.001	0.001	0.005
STRAIGHT TUBE (INTRAUTERINE TANDEM)	155 MG.	2 MIN. 20 SEC.	0.002	0.004	0.02
RADIUM PLAQUE (SKIN LESIONS, CONTACT)	95 MG.	4 MIN.	0.001	0.004	0.02

Chart III

number of milligrams of radium used in each individual applicator is indicated in the chart, but at all times during the measurements there was a total of 215 mg. of radium in the well of the protective device. *We do not advise having more radium in the well than is to be used in any one preparation.* This excess amount was placed in the well during these measurements to show the high degree of efficiency of the device and acces-

TYPE OF APPLICATOR	TOTAL AMOUNT OF RADIUM PER APPLICATOR	EXPOSURE IN r TO THE INDIVIDUAL WHILE LOADING AND UNLOADING APPLICATORS FOR A SINGLE PATIENT		
		BODY	FOREARM	FINGER TIPS
T-TUBE AND COLPOSTAT WITH TOTAL OF 215 MG. RADIUM ON BLOCK.	75 MG.	0.004	0.006	0.025
T-TUBE AND COLPOSTAT WITH NO ADDITIONAL RADIUM ON BLOCK.	75 MG.	0.001	0.002	.008

Chart IV

sory instruments. The time and exposure include the loading and unloading, and redistribution of radium. The timing was done by stop watch. The exposures for the body, forearm, and finger tips were measured with three 0.25 r full scale chambers, each division on the scale representing 0.005 r. The chamber measuring the body irradiation was strapped to the back of the device at the level of the chest. The measurement for the forearm was obtained by strapping a second chamber to the medial aspect of the wrist of the operator and a third chamber was held at the finger tips of the operator by a second individual.

In order to show the minimal exposure in roentgens under ideal loading conditions the measurements in Chart IV were taken. Here the multisectional, intra-uterine T-tube and colpostat containing a total of 75 mg. of radium, with a total of 215 mg. of radium in the well on the radium block, were loaded and unloaded. The procedure was then repeated with only 75 mg. of radium in the well. Here one notes three to four times less exposure in the latter procedure over the former. *We strongly recommend the latter procedure in all instances.*

THE VALUE OF THE NEW RADIUM PROTECTIVE DEVICE AND TECHNIQUE IN A GENERAL HOSPITAL

The Strong Memorial Hospital and Rochester Municipal Hospital, with a combined bed capacity of approximately 550 beds,

during 1940 cared for 401 cancer patients admitted to the various services during the year. Chart v represents the number of times the various applicators were used with

RADIUM APPLICATIONS USED IN STRONG MEMORIAL HOSPITAL AND ROCHESTER MUNICIPAL HOSPITAL IN 1940		
1	T-TUBE AND COLPOSTAT	26
2	T-TUBE ONLY	6
3	STRAIGHT INTRAUTERINE TANDEM	27
4	INTERSTITIAL NEEDLES	14
5	PLAQUES (LOCAL SKIN TREATMENT)	27
6	SPECIAL APPLICATORS FOR OTOLOGY	33
7	SPECIAL APPLICATORS FOR UROLOGY	349
	TOTAL PREPARATIONS	482

CHART V

a total of 482 different treatments. There were 33 special otological applications and 349 urological applications. In these instances the radium is kept in special applicators which are not loaded and unloaded so that handling is almost entirely avoided.

The annual exposure from radium for the year 1940, not including the special otological and urological treatments, is shown in

TYPE OF APPLICATION AND TIMES USED IN 1940	AVERAGE AMOUNT OF RADIUM AT EACH APPLICATION	EXPOSURE TO BODY IN r	EXPOSURE TO FOREARM IN r	EXPOSURE TO FINGER TIPS IN r
26 - T-TUBE AND COLPOSTAT	75 MG.	0.104	0.156	0.650
6 - T-TUBE ONLY	55 MG.	0.018	0.030	0.120
27 - STRAIGHT TUBE	155 MG.	0.054	0.108	0.540
27 - LOCAL PLAQUES	95 MG.	0.027	0.108	0.540
14 - 10 - 2 MG. NEEDLES	20 MG.	0.056	0.042	0.140
TOTAL ANNUAL EXPOSURE IN r		0.259	0.444	1.990
AVERAGE DAILY EXPOSURE IN r		0.0007	0.0012	0.0055

CHART VI

Chart VI. Here it is seen that the average daily exposure to the body is 0.0007 r; to the forearm, 0.0012 r; and to the finger tips, 0.0055 r, provided that the same individual assumed full responsibility for all radium preparations.

Exposure from loading and unloading a T-tube and colpostat represents the greatest exposure from any combination of applications we are called upon to prepare (Chart III). If we suppose that we received this same exposure from each of the 482 preparations, which certainly is not true, we would have received an annual exposure

482 APPLICATIONS IN 1940	TOTAL EXPOSURE IN r FOR 1940 IN LOADING AND UNLOADING APPLICATORS ASSUMING THAT A SINGLE INDIVIDUAL DID ALL THE WORK.		
	BODY	FOREARM	FINGER TIPS
TOTAL ANNUAL EXPOSURE	0.482	0.964	3.856
AVERAGE DAILY EXPOSURE	0.0013	0.0026	0.0105

CHART VII

far less than what is still considered to be the maximum safe level. If exposure from loading and unloading the T-tube and colpostat without additional radium in the well (see Chart IV) is multiplied by 482, we should get an annual exposure to the body of 0.482 r; to the forearm of 0.964 r; and to the finger tips of 3.856 r. This gives us an average daily exposure to the body of 0.0013 r; to the forearm of 0.0026 r; and to the finger tips of 0.0105 r (Chart VII), provided the same individual assembled and disassembled all the applicators, which is not true in most institutions.

From these data, obtained from actual measurements of time and exposure in roentgens for each of the several representative applicators and then multiplied by the actual number of times these applicators were used in the year 1940, we note a very low average daily exposure. It seems that

in the average general hospital of like size and activity the same individual could handle all the radium and very nearly approach an average daily exposure of 0.005 r. Such an ideal can be approached if the department is so organized as to permit a rotation of the personnel responsible for the preparation of the radium applicators.

CONSTRUCTION OF NEW RADIUM PROTECTIVE DEVICE

Figure 6 shows an isometric drawing representing a view of back, side, and top. Figure 7 represents a view showing side, front, and interior. In this latter view can be seen the location of the vise, universal joint, and lead collar on remote control shaft. The corners of the interior are all reinforced with additional lead which makes a total thickness in these areas of 3 inches.

In the actual construction four metal forms can be made representing back, side, bottom, and top according to specifications in the isometric drawings. These forms are filled with molten lead. After cooling and removal of the forms, the respective parts are set in place and fused with a blow torch, the corners are then filled with molten lead

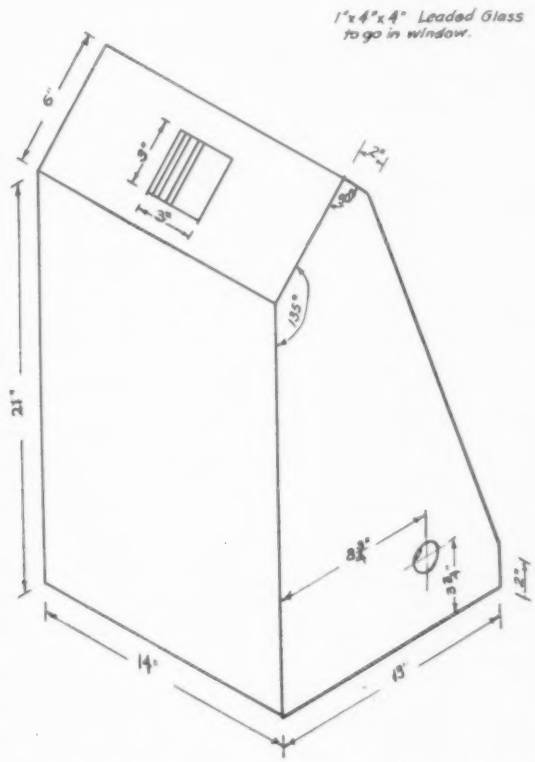

Fig. 6. Isometric drawing of new radium loading protective device showing a view of side, back and top.

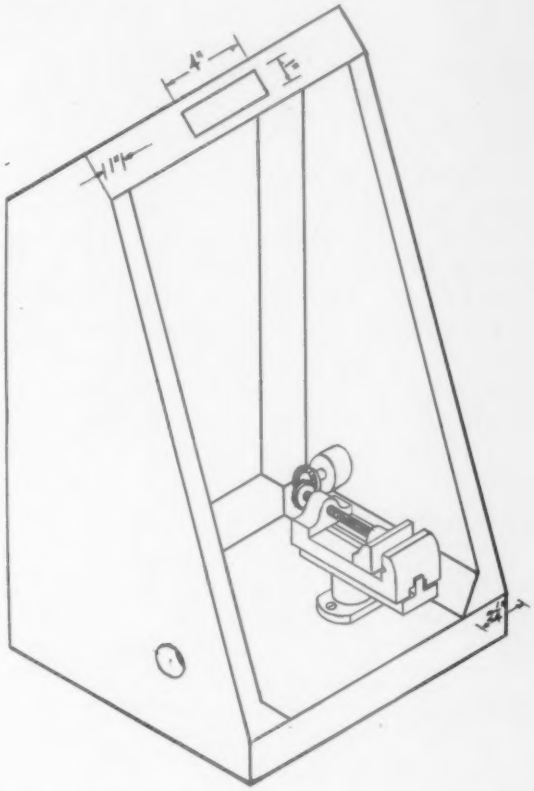

Fig. 7. Isometric drawing of new radium loading protective device showing side, front and interior views.

by means of a blow torch to fill in any possible crevices and to add structural strength. In making the form for the top, a window must be left which is 4 by 4 by 1 inch and open to the front edge, with a 1 by 4 by 4 inch opening on front and back surface of top to accommodate the 4 inch square lead glass window. To minimize the cost of construction, the window has been reduced to this size from a much larger window in our present model. Should a larger sized piece of lead glass be available or should this additional expense not be an objection, we feel that the larger size is somewhat more

advantageous. We have noted a tendency for the smaller window to fog from the operator's breath if the room is cool. The device should be radiographed by using 200 mg. of radium for about twelve hours and placing film all over the outside surfaces and corners, to detect holes.

The hole in the left wall to permit the passage of the solid brass remote control shaft is now made. The vise is securely screwed to the base of the contrivance toward the left side and forward. A small soft piece of leather is glued to the approximating surfaces of the jaws of the vise to prevent crushing of the applicators when the grip of the vise is tightened. The lead collar is now placed over the inner end of the remote control shaft and secured in place. A brass bearing is placed in the hole in the wall through which passes the shaft of the remote control handle. The outer end of the shaft is now passed through the left wall and a small wheel secured to its end so that it can be grasped with the left hand for opening and closing the vise. The hole on the right side is to permit the passage of the head of the long handled instruments which manipulate the radium applicators.

The entire outside of the device, with the exception of the bottom and aforementioned apertures, is covered with 1/4 inch of plywood, which not only protects the operator's body from some of the soft secondary radiation from the lead produced by gamma-ray bombardment but also gives a finished appearance.

Following is an itemized account of the cost of material used in construction. The actual construction was carried out in our hospital machine shop.

Lead—536 lb. at $0.08 per lb.	$42.88
Lead glass—16 sq. in. at $0.36 per sq. in.	5.76
Vise	3.85
Material for accessory instruments, etc.	5.10
Total cost of material	$57.59

DISCUSSION

The need for better and more general knowledge of the danger in the handling of radium is again called to the attention of radiologists. The increasing use of radium, both medically and commercially, will increase the exposure hazard to the personnel involved in its supervision and care. We have described a new type of radium loading protective device and discussed a technique which enables the rapid loading and unloading of the various radium applicators with a minimal exposure. The actual exposure in roentgens for loading and unloading the various applicators has been presented in conjunction with a comparison of the exposure received from an old type of protective device.

The increased safety factors with the former is possible because of three factors: (1) increased lead protection; (2) the necessary relatively long working distance of the of the body and hands from the radium, and (3) the increased speed which can easily be developed in the loading and unloading process.

The average daily exposure factors in roentgens from the handling of radium in a hospital of 550 beds in 1940 has been ascertained.

CONCLUSIONS

1. A new type of radium loading protective device is described which is cheap in construction and efficient in time saving and in effecting a low exposure in roentgens to the operator.

2. We believe that with reasonable care the average daily exposure from radium should not exceed 0.005 r in the average hospital.

We wish to express our appreciation to Mr. Charles Albert and Mr. Joseph Ebert of the Maintenance Department of Strong Memorial Hospital and Rochester Municipal Hospital for the actual construction of the protective device and accessory instruments, and their helpful suggestions regarding the various details of design.

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ARTIFICIAL DECREASE OF THE RADIOSENSITIVITY OF THE SKIN AND MUCOUS MEMBRANES IN ROENTGEN THERAPY*

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THE possibilities of deep roentgen therapy, particularly roentgen therapy of cancer, are limited by skin tolerance. The skin dose is the maximum limit beyond which it is impossible to go in treating a deep lesion; and though the depth dose may be increased in general by improving the depth dose by the use of more penetrating rays and, for central lesions by using cross-fire technique, it nevertheless frequently happens that, in spite of these devices, the depth dose is not large enough to destroy lesions which are not very sensitive to irradiation or which are accessible through only one field.

An attempt has been made abroad to improve radiotherapeutic technique either by increasing the sensitiveness of the tissue to be destroyed or by decreasing that of the tissue to be spared, particularly the skin. I attempted to bring about desensitization of the skin and I was able to accomplish it by a method much simpler and more effective than those which have been in use heretofore.

Radiosensitivity is not a constant property of the skin, but one that varies at different times during the physiological life of the tissue. Schwarz[1] emphasizes the special reaction of organized tissues to roentgen rays. Other physical agents such as heat, cold, electricity and mechanical or chemical agents, cause the same changes, such as coagulation, freezing, oxidation, electrolysis or crushing of organized tissues no matter whether they are living or dead. But with roentgen rays, on the contrary, doses even much larger than those which seriously injure a living tissue do not cause any visible change in the same tissue when it is dead.

It may be assumed, therefore, that a change in the vital processes of a tissue will be accompanied by a change in the reactions of the tissue to roentgen radiation. Schwarz in 1909 showed experimentally that anemia from pressure decreases considerably the sensitivity of the skin to radium. In 1911 Schmidt found that strong pressure brings about inactivity of a dose of roentgen radiation which, without pressure, would cause a second degree skin reaction. Gudzent in 1920 attributed this difference in sensitivity to a physical phenomenon and held that the pressure eliminated secondary radiation emitted by the iron in the hemoglobin of the circulating blood; but Schwarz and Schmidt, having found a decrease and not an increase of radiosensitivity in passive congestion, in which the volume of blood is increased, showed that it was a question of a biological not a physical, process. And the experiments of Rahm and Koose in 1926 on Thiersch grafts and the skin of mice showed that the radiosensitivity of a living tissue is suspended if its connections with the body are severed, and they inserted skin grafts which had been given three to five times the erythema dose in vitro without their showing any lesions from the irradiation.[2]

The method used in practice for desensitizing the skin has been to act on its vascularization and innervation and to suspend more or less completely the action of

[1] In Rieder and Rosenthal. Lehrbuch der Röntgenkunde. Leipzig, 1928, p. 68.

[2] See Rahm. Roentgen therapy in surgery. *Neue deutsche Chir.*, 1927, *37*, 304.

* Translated from the French by Audrey G. Morgan, M.D., Los Angeles, California.
† See Lehmann, P., *Compt. rend. Acad. d. sc.*, June 16, 1941, p. 1103.

FIG. 1. March 25, 1941. Crown-shaped erythema after irradiation of the breast with 3,000 r from February 20 to March 12, 1941, at 200 kv.

the vessels and nerves of the irradiated part during irradiation. Two methods of procedure have heretofore been recommended for the desensitization of the skin:

A. *Mechanical actions.* Jessen and Rawuski, Schwarz, Christen, Schmidt, Seitz and Wintz used pressure, either exercising pressure directly with compressors of different types or with rubber balloons, or on the limbs, by constriction with rubber bands. According to Schwarz, the pressure brought about in this way increased the tolerance of the skin by 100 per cent.

B. *Physiological actions.* Reicher and Lenz, and Freud introduced adrenalin-novocain by ionization; they applied to the positive pole a compress wet with the active solution and passed through it a current of 10 milliamperes for twenty to twenty-five minutes before irradiation.

These methods of desensitization did not come into general use, doubtless because they were not very practical. Constriction can only be used for the limbs. Pressure on the trunk strong enough to bring about the desired action can rarely be borne by the patient. And the use of ionization is a complication which roentgenologists are apt to reject, even in techniques that require only a few roentgen treatments.

A series of articles appeared describing experimental research by Zondek in which the absorption of folliculin by the skin was described, which had resulted from the use of salves for hypertrichosis, acne, leukoplakia and vulvar pruritus.[3] These suggested the use of active salves for the desensitization of the skin in patients who had to be irradiated for postoperative recurrences of cancer, and whose skins, sensitized by surgical trauma, offered little resistance to the usual skin doses. I at first made use of several commercial antihemorrhoidal salves which contained vasoconstrictors and anesthetics and which did not contain any metal excipient which could have made the irradiation injurious. And before every treatment I lightly massaged the skin over the field of irradiation with these salves.*

I found that in patients treated in this way only slight pigmentation or none at all was produced on skins which should have reacted strongly to the doses given.

I then thought of using larger doses than the usual ones for severe cancers and gave the following treatment to a spindle cell cancer of the left tonsil with masses of enlarged lymph nodes (Roch, Case 2,710 of my service): From June 8 to July 4, 1939, 4,200 r was given through a single field with 280 kv., filtered through 1.5 mm. copper and 2 mm. aluminum, focus-skin distance 80 cm.; from July 17 to August 2 1939, 1,200 r over the same field and from August 16 to October 19, 2,800 r, or a total

[3] Mussio-Fournier, J. C., Morato-Manaro, J., and Albrieux, A. Local action of hormones. *Presse méd.*, 1939, *47*, 844–848.

* I extend thanks to Mlle. Mong, superintendent, and to Mmes. Souyri, Moisiard, Gressillon and Stephan, nurses on my service, without whom I could not have treated, and especially followed after treatment, my patients at the Bichat Hospital.

of 8,200 r in four months. This resulted in only a dark pigmentation without erythema or desquamation.

As a result of this treatment I repeated my experiment, first using doses larger than the usual skin doses and then decreasing the exposure time of the doses. After having used applications of simple and mentholated vaseline, to prove the part played by the active drugs, without obtaining any results, I used a salve with a base of vaseline and lanolin containing adrenalin and stovaine, excluding the other drugs contained in the antihemorrhoidal salves which I had used before. In September, 1940 as vaseline and lanolin had become scarce, I used lard as an excipient and found that with lard the desensitization seemed to be more complete, doubtless as a result of more complete absorption of the drugs.

I have tried, more recently, to determine whether both the adrenalin and the stovaine were active agents; but I did not think I had the right to risk making the patient lose the benefit of certain desensitization by changing a formula the results of which were known, and I was not able to draw may definite conclusion on this point from the few experiments with semipenetrating rays to which I limited myself with a stovaine salve without adrenalin.

In the course of these experiments I saw the efficacy of the desensitizing salve demonstrated by finding skin reactions in the form of *pigmentation or annular epidermitis* in a crown around a circle of intact skin in subjects on whom the salve had not been applied entirely to the edge of the field of irradiation (Fig. 1).

It is also noteworthy that the variations in sensitivity of different skins are more marked with the large doses permitted by desensitization than with the usual roentgen therapy. In some very rare cases desensitization seemed less complete than usual, either because the permeability of the skin was defective or because there are, as Freud claims, skins that are resistant to adrenalin.

It would seem also that in summer the use of the salve is less effective, because of the intense heat, which seems to be related to perspiration and may be avoided by preliminary cleansing of the skin.

Fig. 2. April 30, 1940. Irradiation of the axilla with 5,000 r from March 13 to April 26, 1941, at 280 kv.

In one case (Case 4,642) the desensitizing salve did not prevent the appearance of a slight skin reaction with desquamation and an inflammation of the buccal mucous membrane after the administration of only 1,750 r with 200 kv. through two fields, one over the right submaxillary and one over the left carotid, or a total of 3,500 r in thirty-four days; but the patient had kept in a bridge during some of the treatments which acted as a radiator of secondary rays, and only the irradiated field had been desensitized for each treatment, while the non-irradiated field was also receiving radiation through a cross-fire action.

The hair follicles do not seem to be affected by desensitization and the epi-

lation dose did not seem to be affected by the desensitizing salve, a fact which it seems to me ought to permit of interesting applications.

At present, after experience acquired in several hundred treatments in the course of which I varied the formula and increased the doses progressively I use the following formula:

Adrenalin	0.01 cgm.
Stovaine	1.00 gm.
Benzoinated lard	100.00 gm.

Before treatment and after cleaning the skin, this salve is applied with a cotton applicator over the whole field to be irradiated. The skin dose which produces a moderate pigmentation without desquamation four weeks after irradiation is, for a skin which has not undergone any surgical trauma, prolonged impregnation with antiseptics or any other cause of sensitization as follows:

3,500 to 4,000 r instead of 2,000 r with 200 kv., filtered through 1 mm. copper and 2 mm. aluminum

6,500 r instead of 3,000 r with 280 kv., filtered through 1.5 mm. copper and 2 mm. aluminum.

These doses were applied to fields 20 cm. in diameter over a period of three to four weeks, measurements being made with the Strauss dosimeter.

With 150 kv. I did not increase the doses in the same proportion, as there is less occasion to increase the doses for patients treated with this voltage. However I have used 1,400 r instead of 1,000 r in the treatment of plantar warts or of Dupuytren's disease.

In a certain number of cases of severe cancer accessible through only one field I even exceeded the doses given above, either by prolonging the irradiation time beyond four weeks or by giving another series of irradiations after an interval of ten to thirty days. For instance (Case 4,741) I gave a dose of 6,000 r with 200 kv. to a scirrhous cancer of the right breast without any reaction except a slight desquamation five days after the end of the irradiation with return of the normal appearance of the skin eight days later. In one case (Case 4,751) of large ulcerated exuberant tumor of the left cheek I gave 6,000 r in forty days without causing any skin reaction. No reaction appeared after 6,000 r in forty days in a case of large epithelioma of the skin of the left leg (Case 4,832).

In an epithelioma of the right lower maxillary region (Case 4,724) the skin desquamated without erythema after the end of irradiation with 280 kv., giving a dose of 7,000 r in thirty days; a month later the skin appeared to be intact and not atrophied. An osteosarcoma of the left knee (Case 4,823) was given 8,000 r in thirty days, 6,000 r on the anterointernal surface, 2,000 r on the posterior surface through large fields; the skin was erythematous without pruritus at the end of the irradiation; some pigmentation persisted thirteen days later.

Intense irradiations may be repeated on desensitized skin without injury after shorter intervals than in the usual treatments. A patient with a large exuberant tumor of the left breast (Case 4,348) was given 5,500 r in twenty-nine days, then after a rest of thirty-five days, 4,500 r in twenty-one days on the same field, or 10,000 r in three months at 280 kv. There was no skin reaction. Another case (Case 4,654) was given 5,000 r in twenty-seven days at 280 kv. for a glandular tumor of the right carotid region, and then after a rest of thirty days 5,000 r in twenty-seven days, or a total of 10,000 r in seventy-four days, the skin remaining intact.

I applied the same technique of desensitization to the pharyngolarynx, using glycerin as an excipient. As complete a painting as possible of the mouth, the tongue and even of the pharynx before each irradiation saves the patients the inflammation of the mucous membrane and the glossitis with disturbance of taste which is so painful toward the end of the irradiations.

In the same way it is possible with

suppositories of adrenalin and stovaine to prevent or lessen the proctitis which often accompanies intense irradiation of the pelvis.

In the eye a desensitizing collyrium prevented conjunctivitis, but the cornea was not protected by the desensitization.

Late roentgen lesions of the cellular tissue might be feared in patients whose desensitized skin had not reacted to large doses of irradiation. So far I have not seen any induration of the cellular tissue or atrophy of the skin with telangiectases in patients who have been under treatment for more than six months. I was justified in substituting this risk of late roentgen lesions for the risk of earlier death in these cases of cancer involving painful complications, which did not react to the usual dosage of irradiation.

The advantages gained in roentgen therapy by desensitization of the skin may be measured by the increase in depth dose which it represents. Cancer therapy has made a step in advance every time the depth dosage has been increased by increasing the voltage of the apparatus. According to Mathey-Cornat the depth dose rises from 38 to 40 per cent of the skin dose with an irradiation at 200 kv. filtered through 2 mm. copper and 1 mm. aluminum with a focal distance of 50 cm. to about 50 per cent for an irradiation at 300 kv. with a focal distance of 60 cm., with fields of the same size in the two cases.

Holthusen and Goggwitzer, Failla, and Mudd claim that the depth dose is increased from 10 to 15 per cent in changing from 200 kv. filtered through 0.5 mm. copper to 700 kv. filtered through 5 mm. copper. Gunsett claimed to have obtained an improvement of 20 per cent in depth dosage on changing from 200 to 400 kv. and of 30 per cent in changing from 200 to 520 kv.[4]

These relatively small gains can be obtained only with apparatus the cost of which rises rapidly with increased voltage and only a limited number of which exist. By the use of desensitization of the skin using the ordinary 200 kv. apparatus the skin dose and therefore the depth dose can be doubled, the depth dose being increased in this way from 40 to 80 per cent of the ordinary skin dose.

It may therefore be said that desensitization of the skin, by increasing the limits of the skin dose, nullifies the advantages of high voltage in roentgen therapy; and as a matter of fact I have found in my service at the Bichat Hospital that the therapeutic results have become as good with 200 kv. as with 300 kv. by making use of the increased skin tolerance brought about by desensitization of the skin.

Desensitization of the skin, therefore, seems to me to offer unhoped for possibilities in the radiotherapy of cancer, thanks to a very simple technical procedure and I have already found a marked improvement in the immediate results of treatment, particularly in cases of severe cancer, those insensitive to irradiation and those accessible through only one field, such as cancers of the breast and of the larynx. And in current roentgen therapy it offers a margin of safety which protects the patient from the risks of radiodermatitis.

[4] La radiothérapie a voltage élevé. *J. de radiol. et d'électrol.*, 1936, *20*, 505–522.

CAVERNOUS HEMANGIOMA OF THE FACE IN AN INFANT TREATED WITH RADIUM

REPORT OF A CASE*

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ANGIOMATA of the skin are usually benign congenital anomalies and in about 75 per cent of the cases are present at birth. Although they may occur on any part of the body, about 55 to 60 per cent occur about the head, and about 55 per cent occur as single lesions. They seldom develop in infants after the first year. In reference to etiology the most plausible is the development from embryonic rudiments (Ribbert's theory). Histopathologically the capillary angioma (nevus flammeus and vasculosus) consists of a fine network of capillaries, while the cavernous angioma is composed of dilated blood spaces with thin walls.

Angiomata or vascular nevi generally occur in three forms:

(1) Nevus flammeus (portwine mark)
(2) Nevus vasculosus (strawberry mark)
(3) Angioma cavernosum (cavernous angioma).

(1) *Nevus flammeus or portwine mark* is a pink to blue red area, in size from that of a finger nail or smaller to that of the palm of a hand or larger. It is not raised above the level of the surrounding skin, and usually appears at or shortly after birth. The light pink lesions on the nape of the neck tend to disappear in a few months or years. This type of lesion is not a suitable one for roentgen or radium therapy, although satisfactory response has been seen in small lesions treated early. Grenz rays and the Kromayer lamp have been used.

(2) *Nevus vasculosus or strawberry mark* is a slightly raised, bright red to blue-red lesion, smooth or verrucous. Treatment with radium and carbon dioxide snow produces satisfactory results. The chief advantage of radium therapy is the lack of pain or reaction, both of which occur with the use of carbon dioxide snow. With radium it takes a long time to produce results and may require one to two years for maximum improvement.

(3) *Cavernous angiomas* vary in size from that of a pea to that of a tennis ball or larger. They may be diffuse or circumscribed and are often surmounted by a nevus vasculosus. Radium is the treatment of choice.

The earlier the treatment is instituted, the better and quicker the results. It is advisable to begin before the child is three months old, and two months might be considered as the minimum age—certainly during the first year of life. Early treatment is recommended for three reasons:

1. The endothelial cells lining the vascular spaces of the tumor are more radiosensitive during their embryonic and early life.
2. Early treatment will prevent most lesions from becoming larger and spreading laterally.
3. Residual effects of irradiation such as scarring and increased pigmentation decrease as the years go on, thereby producing better cosmetic results.

The treatment of vascular nevi can be divided into two classes: (1) non-radiation; (2) radiation therapy.

(1) *Non-radiation.*
(*a*) Freezing by solid carbon dioxide snow is the oldest method useful for small lesions, preferably on unexposed parts of the body.
(*b*) Surgical excision either with the scalpel or endotherm knife.

* Presented at a meeting of Society of Lebanon Hospital, January 13, 1942.

(*c*) Injection of sclerosing solutions, such as mixtures of quinine and ethyl carbamate, sodium morrhuate (5 per cent solution, etc.).

(2) *Radiation Treatment by Roentgen Rays or Radium.*

Radium has become the agent of choice in this country. It may be applied by various techniques, as moulds, flat applicators, or implantation of needles (interstitial method). I have always preferred surface applications in small doses at intervals. Ulceration of the nevus and secondary infection are no contraindication to radium therapy except that the doses should be smaller than for the non-infected type.

REPORT OF CASE

E. C., an infant, aged ten weeks, was referred to me, August 2, 1939, about twenty-eight months ago with the following history: Birth—full term, instrumental delivery, bottle-fed, no other children. At birth, a bluish-red irregular swelling was noticed over and in front of the right ear, extending over to the angle of the right side of the mouth, elevating and protruding the lobe of the right ear, making it more prominent than the left ear. Apparently not painful nor tender, and increasing in size. Local examination showed an irregularly outlined, multilobulated soft, compressible, bluish-red swelling in front of the right ear, in the region of the parotid gland extending partly into the external auditory canal posteriorly, and anteriorly involving the entire parotid area with irregular margins and extending along the right side of the face as far as the angle of the right side of the mouth almost to the margin of the lower lip. The ear appeared prominent and elevated somewhat by this swelling, which apparently was not painful nor tender.

The diagnosis was hemangioma of the right side of the face. Radium therapy was instituted on August 3, 1939. The technique consisted of dividing the entire involved region into five smaller areas, treating one to three areas at a time, with surface radium applicators, total at each treatment varying from 25 to 50 mg., with

FIG. 2. Four months after treatment.

FIG. 1. Before treatment, aged ten weeks.

FIG. 3. Twenty months after treatment.

filtration of 1 mm. brass to 0.5 mm. platinum, at a distance of 0.25 cm. for one to two hours, dosage being from 25 to 37.5 mg-hr. At the beginning the intervals between treatments were three to four weeks and later the intervals were longer. From August 3, 1939, to April 17, 1941, a total of twenty-two radium applications was made to the entire lesion, with a total of 840 mg-hr. About six weeks from the commencement of treatment, there was visible evidence of diminution in swelling and change in color to a paler hue, which continued to improve slowly and gradually so that now there is present a soft whitish area over the site of the original lesion with scattered irregular spots of dilated capillaries. The area involved by this rather extensive lesion has shown a very remarkable improvement with shrinkage and replacement by a smooth, almost normal skin.

The case presented shows what can be accomplished with radium therapy, judiciously applied, by surface applications in small amounts, at intervals, over a prolonged period in the treatment of properly selected cases of vascular nevi in the skin of infants.

295 Central Park West,
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Vol. 49, No. 6

ISODOSE CHARTS FOR FIELDS OF SPECIAL USEFULNESS IN THE TREATMENT OF CANCER OF THE UTERINE CERVIX

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DURING a study of the distribution of radiation at various important points in the pelvis in the treatment of cancer of the cervix, detailed information was required concerning the amount of radiation at the periphery and outside a direct beam. When two beams of roentgen rays are em ployed close together as in a pelvic cycle, a knowledge of the amount of peripheral radiation is required in order to calculate doses in the region where the beams overlap. Depth dose tables[3,4] in the literature give doses only in the central axis of the beam. In articles[3,5] where isodose curves were published, it was usually not possible to interpret doses in the peripheral portion of the beam or in the region outside the direct beam with sufficient accuracy for our study. Arneson and Quimby[1] published isodose charts for the pelvis in which there was a separation of 2 cm. between adjacent parallel beams. Reinhard and Miers[6] published isodose curves for two adjacent oblique fields inclined at various angles towards each other. Apart from these and similar publications which, however, treat only of special cases of separation and angulation, the peripheral depth doses have not received the attention that their importance warrants. From the point of view of treating a malignant neoplasm, the doses at the periphery of a beam are equally as significant as the doses in the central axis. In order to obtain this information in sufficient detail, special studies were undertaken.

Two fields were studied. The first measured 10 by 15 cm. and was selected because it is the most frequent size used in a pelvic cycle. The second was a 15 by 15 cm. field, divided by a centrally placed lead strip 4 cm. wide, into two narrow fields, 5.5 by 15 cm. each. This divided field is a modification of a special pelvic field described by Tod and Meredith[7] for irradiation of the parametria in the treatment of cancer of the cervix. Its special usefulness lies in the fact that the midline structures of the pelvis, i.e., bladder, rectum and cervix, and the lateral structures of the pelvis, i.e., head and neck of the femur, are spared direct radiation.

It is well known that the depth dose depends upon the quality of radiation, target-surface distance, and size of field, as well as the atomic number, density and dimensions of the substance irradiated. What is not so well recognized is that the depth dose also depends upon the method of collimating the roentgen-ray beam. During our studies, we observed that if the roentgen-ray beam was collimated by means of a limiting diaphragm placed at the upper end of a cone, the depth dose in the peripheral region of the beam was considerably less than the dose in the central axis at the same level. When the method of collimation was altered by removal of the limiting diaphram and the use, instead, of a diaphragm only at the lower end of the cone where it is in contact with the phantom, the peripheral depth dose increased appreciably while the dose in the central axis remained practically unchanged. The problem of beam collimation and limiting diaphragms has been the subject of an earlier publication.[8] It is very likely that the variations in published isodose curves, especially with regard

* Presented at the Eastern Conference of Radiologists, New York, N. Y., Jan. 23–24, 1942.

to doses at the periphery of the beam, may have been occasioned, at least in part, by differences in methods of collimation.

EQUIPMENT

A Villard type generator was operated at 200 kv. (peak) and 20 ma. A filter of 0.75 mm. Cu. and 1.0 mm. Al was used in addition to the inherent filtration of the roentgen tube and tube head. The half-value layer measured 1.15 mm. Cu. The target-surface distance was 80 cm. The roentgen-ray beam was collimated at the surface of the phantom by means of a cone with lead-lined walls. No other limiting diaphragms were used.

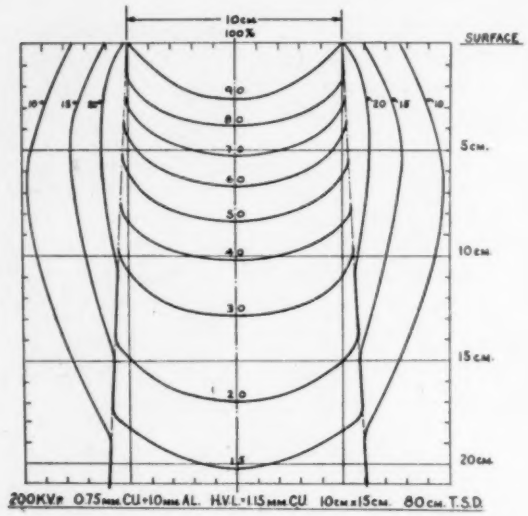

FIG. 1. Isodose chart for 10 by 15 cm. field. Backscatter: 36 per cent.

EXPERIMENTAL PROCEDURE

The depth dose measurements were made in a laminated "masonite" phantom, previously described by Braestrup and Blatz.[2] The phantom measured 30 by 30 cm. in area and 45 cm. in depth. Its density was unity. A thimble type ionization chamber was used, 0.72 cm. in diameter and 2.30 cm. long, permanently connected to an electrometer. The plane of measurement was taken through the central axis of the roentgen-ray beam and across the width of each field. In order to secure a nearly uniform dose distribution throughout the ionization chamber, its axis was placed at right angles to the plane of measurement. No readings were taken through the edges of the direct beam in the phantom. Instead, roentgenograms were made to determine the exact location of these edges at the various levels. Special precautions were taken to secure accurate alignment of the beam with respect to the phantom and the ionization chamber in order to avoid errors which even slight angulation might cause.

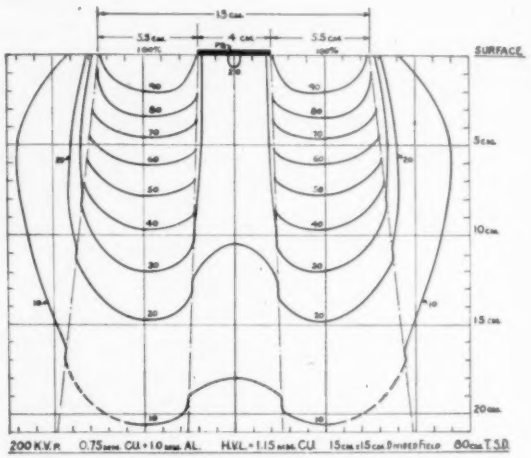

FIG. 2. Isodose chart for 15 by 15 cm. divided field. Backscatter: 31.5 per cent.

RESULTS

The results of these studies are indicated in the form of isodose curves. The backscatter factors were found to be:

10 by 15 cm. field.....	1.36 (36%)
5.5 by 15 cm. field.....	1.315 (31.5%)

The value for the divided field was higher than might be expected from such a narrow field. The increase was due to scattered radiation from the adjacent field.

DISCUSSION

It is quite evident that the beams are sharply defined in the phantom. The sharp gradients in the isodose curves coincide with the geometric outlines of the beam. The sharp definition of the beam in the phantom

is due largely to the method of collimation. Another factor, however, is that, in our experiments, measurements in the edge of the direct beam were purposely avoided. Such measurements would not reveal the true gradient of dose in this region but instead only an average of the intense radiation in the direct beam and the weak radiation outside the direct beam. Therefore such measurements would be misleading in the plotting of the isodose curves and would tend to obscure the sharpness of the gradient at the edge of the beam. This factor may also account for the smoothness of the isodose curves through the edges of the beam as noted in many publications. It is also of interest to note that, in the region outside the direct beam, the intensity of radiation depends upon the distance from the edge of the direct beam rather than the depth. The results for the 10 by 15 cm. field are in close agreement with the recently published isodose curves of Reinhard and Goltz.[5]

From the isodose curves for the 10 by 15 cm. field, the amount of radiation due to overlap from adjacent fields can be determined for any degree of separation or angulation.

The isodose curves for the 15 by 15 cm. divided field show that it is possible to obtain two narrow, sharply defined, divergent beams with the intervening region and the outer regions of relatively low intensity. The advantages of this arrangement are obvious where it is desired to deliver roentgen radiation only to the parametria in the pelvis when radium has been used to give a maximum dose to the cervix. The divided field method provides a greater degree of accuracy of set-up than is possible if each field were set up separately. There is also another advantage of greater economy since two fields are treated simultaneously.

The authors wish to acknowledge with thanks the technical assistance given by Charles J. Wurmfeld, P.E., in the construction of the isodose curves.

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Publisher: CHARLES C THOMAS, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich., Office of publication, 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

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EDITORIAL

CALCIFIED PULMONARY LESIONS

SINCE the comprehensive report of Sayers and Meriwether[1] on miliary lung disease due to unknown cause, numerous reports have appeared dealing with this subject. Sayers and Meriwether made their original report as a result of the examination of several thousand individuals in the mines in and around Picher, Oklahoma, and of the subjects with whom they were dealing 90 per cent were born in Missouri, Oklahoma, Kansas, Arkansas and Illinois, and the majority came from rural districts or had spent several summers in the harvest fields.

More recently an article by Olson, Wright and Nolan[2] calls attention to an epidemiological study of calcified pulmonary lesions in an Ohio county. It had been noted previously that there is a high prevalence of pulmonary calcification in certain areas of the United States, and some observers, notably Gass and his co-workers, and Lumsden and Dearing, have pointed out that such calcifications are common in or adjacent to the Appalachian Plateau.

Prior to the report of Sayers and Meriwether the presence of miliary-like calcifications in the lung fields was interpreted as evidence of primary or first infection tuberculosis but of the 125 cases of "typical miliary lung disease" found in their study, tubercle bacilli were present in only 2 of 88 cases in which examination of the sputum was made. They believed that the presence of miliary calcification in the lung fields did not necessarily justify the conclusion that the patient had had miliary tuberculosis with subsequent healing of the lesions but that the condition might be due to some other cause, possibly to a fungous infection.

Gass and his co-workers, and Lumsden and Dearing, found from their studies that approximately half of the young individuals whom they studied with pulmonary calcifications were tuberculin negative.

These observations have aroused considerable interest and also considerable controversy and it has been shown from studies of various investigators, notably Lumsden and Dearing, that there are great differences in the prevalence of pulmonary calcification in different states and that these variations not only occur in different states but sometimes also in closely adjacent counties of the same state. It was observed that this geographic distribution in pulmonary calcification was associated closely with the occurrence of limestone and chert formations.

In an attempt to clarify some of the observations, Olson, Wright and Nolan set about to determine the relationship between the presence of pulmonary calcification and exposure to tuberculosis, ascariasis, and other specific diseases. They were particularly interested in the study of the relationship of *Ascaris* infection to pulmonary calcification. The selection of the area for this study was Ross County, Ohio, as this county seemed to fulfill the basic requisites for study, namely it was located adjacent to the Appalachian Plateau, an area in which pulmonary calcification was of common occurrence and where tuberculosis mortality was not unusually high. Another factor that determined the selection of this county was that the geology of this particular section was known.

[1] Sayers, R. R., and Meriwether, F. V. Miliary lung disease due to unknown cause. Am. J. Roentgenol. & Rad. Therapy, 1932, *27*, 337–351.

[2] Olson, B. J., Wright, W. H., and Nolan, M. O. Epidemiological study of calcified pulmonary lesions in an Ohio county. *Pub. Health Rep.*, 1941, *56*, 2105–2126.

Olson, Wright and Nolan, statistically analyzing the data from their survey, came to the conclusion that no significant relationship could be demonstrated between contact with known tuberculosis and the occurrence of pulmonary calcification in the group studied, and that this presence of pulmonary calcification as observed in their study had little demonstrable relationship to tuberculosis.

In a further attempt to elucidate the cause of pulmonary calcifications in the absence of a positive tuberculin test or a history of tuberculosis, they considered the possible rôle of parasites in the production of pulmonary calcification since it had been noted that there was a rather close correlation between the distribution of such calcification and the areas of high incidence of *Ascaris lumbricoides* in man. In general, the distribution of pulmonary calcification in the southeastern United States corresponds closely to the area of high *Ascaris* incidence in the Appalachian Plateau and its foothills, the area referred to by Otto and Cort as the endemic center of *Ascaris*.

It has been demonstrated many times by parasitologists that the death of adult worms and the arrestment of parasite larvae in parenchymatous tissues are frequently followed by the production of a granulomatous type of lesion grossly and sometimes microscopically indistinguishable from lesions of this type which characterize certain bacterial diseases.

Shortly after the discovery of the life cycle of *Ascaris lumbricoides* by Stewart, Ransom pointed out the acute manifestations connected with the migrations of *Ascaris* larvae through the lungs of susceptible animals and noted that the same problem should be carefully investigated in human infections. As a result many studies have been carried out in the hope of establishing this point.

In an attempt to throw some light on this subject, Olson, Wright and Nolan carried out extensive soil examinations in the areas where calcification of the lung was prevalent. They came to the conclusion that on the basis of the data furnished by their epidemiological study they were unable either to prove or disprove the possible rôle of *Ascaris* as a causative agent in pulmonary calcification. They believe, however, that until additional evidence is available the parasite in question should not be ruled out as a possible etiological agent in pulmonary calcification.

A further article[3] on the subject of miliary calcification of the lung appears in this issue of the JOURNAL. The miliary lesions in the two cases reported were discovered incidentally in routine examinations of the chest; both cases were studied clinically, bacteriologically and pathologically. The cause of the pulmonary lesions could not be definitely ascribed to disease other than tuberculosis, and taking the findings of the complete study into account, it was believed that the cause for the pulmonary appearance in the two cases was tuberculosis, probably of the primary type. Geever concludes that although the possibility exists that other agents may cause this interesting lung picture, the importance of tuberculosis should not be minimized. He includes an outline of the studies which should be performed whenever an opportunity presents itself to examine a patient who demonstrates the finding of pulmonary calcification in the chest roentgenogram.

It thus appears from the combined studies of various observers that there is in certain areas and states a high incidence of pulmonary calcification which cannot be definitely related to tuberculosis as a causative factor, that these pulmonary calcifications result from an as yet unrecognized disease of very common occurrence which produces pulmonary lesions closely resembling the roentgen appearance of primary tuberculosis, and it is their considered opinion that the finding of pulmonary cal-

[3] Geever, E. F. Miliary calcification of the lung. AM. J. ROENTGENOL. & RAD. THERAPY, June, 1943, *49*, 777-782.

cification, particularly in tuberculin-negative individuals, should not necessarily be assumed to be evidence of infection with the tubercle bacillus. By other observers it is believed that while various causative agents must be taken into account, the importance of tuberculosis should not be minimized.

The many studies carried out on the cause of pulmonary calcification have added greatly to our knowledge of the condition, but in view of their inconclusive nature, further comprehensive studies should be undertaken to establish if possible the definite etiological agent or agents.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: 1943, cancelled.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: Chicago, Ill., June 6, 1943.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: 1943, cancelled.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. J. S. Wilson, Mack Wilson Hospital, Monticello, Ark. Meets every three months and also at time and place of State Medical Association.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Drake Hotel, Chicago, Ill., Nov. 29–Dec. 3, 1943.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL ASSOCIATION
Secretary, Dr. Donald R. Laing, 65 North Madison Ave., Pasadena, Calif. Meets on second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N.Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. Warren W. Furey, 6844 S. Oglesby Ave., Chicago, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Building.

FLORIDA RADIOLOGICAL SOCIETY
Acting Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Fla. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. James J. Clark, 478 Peachtree St., Atlanta, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

RADIOLOGICAL SOCIETY OF KANSAS CITY
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month at a place designated by the president.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOUISIANA RADIOLOGICAL SOCIETY
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. Annette T. Stenstrom, 1218 Medical Arts Bldg., Minneapolis, Minn. One meeting a year at time of Minnesota State Medical Association.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. Hugh F. Hare, Lahey Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. M. M. Pomeranz, 1020 Park Ave., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

NORTH DAKOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Ohio Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

Philadelphia Roentgen Ray Society
Secretary, Dr. R. P. Barden, University Hospital, Meetings first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. R. G. Alley, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Sidney Larson, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho.

St. Louis Society of Radiologists
Secretary, Dr. P. C. Schnoebelen, 462 N. Taylor Ave. Meets fourth Wednesday of each month, except June, July, August, and September, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

Shreveport Radiological Club
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. Herman Klapproth, Sherman, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St., Richmond, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. A. D. Irvine, 540 Tegler Bldg., Edmonton, Alberta.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

CANCER TEACHING DAY

A Cancer Teaching Day, arranged by a number of the medical societies of Utica and of the State of New York, was held at the Hotel Utica, Utica, New York, on June 17, 1943. The program of the afternoon meeting, which was called to order at 4.00 P.M. with Dr. Bradford F. Golly, President of the Medical Society of the County of Oneida, as Chairman, was as follows:

The Management of the Patient with Advanced Cancer. Norman Treves, M.D., New York, N. Y.

Cancer of the Larynx, Bronchi, and Esophagus (illustrated by motion pictures and lantern slides). Chevalier L. Jackson, M.D., Philadelphia, Pa.

Dinner was served at 6.15 P.M., after which the meeting was resumed at 7.30 P.M. with Dr. Bradford F. Golly as Chairman, and the following two papers were presented:

Cancer of the Colon and Rectum. George E. Binkley, M.D., New York, N.Y.

The Significance of Enlarged Lymph Nodes. Lloyd F. Craver, M.D., New York, N.Y.

CAPTAIN ALBERT SOILAND HONORED

On Wednesday, May 5, 1943, the Radiological Section of the Los Angeles County Medical Association celebrated the seventieth birthday of Captain Albert Soiland, M.C., U.S.N.R., with a testimonial dinner at the University Club. About one hundred and fifty of Captain Soiland's friends were present, including Rear Admiral Ralston Holmes, U.S.N., Captain W. H. Michael, M.C., U.S.N., The Honorable Fletcher Bowron, Mayor of Los Angeles, The Honorable Erling S. Bent, Norwegian Consul, Captain Iverson, U.S.N., Captain John Ruddock, M.C., U.S.N.R., Captain Walters, U.S.N., and Captain William E. Costolow, M.C., U.S.N.R.

Congratulatory messages were received from the Crown Prince and Princess of Norway, the Norwegian Ambassador to the United States, Admiral Chester W. Nimitz, CINPAC, Rear Admiral Ross McIntyre, Surgeon General of the United States Navy, Admiral William D. Leahy, Chief of Staff to the President, and many others.

Following a pleasant program of entertainment the principal address of the evening was given by Commander John D. Camp, M.C., U.S.N.R., whose subject was "The Origin and Development of the Science of Roentgenology."

Dr. Soiland was presented with an engrossed scroll bearing the signatures of all those present to which he replied with words of appreciation. As the culmination of the evening Captain W. H. Michael, M.C., U.S.N., presented the fourth gold stripe elevating Dr. Soiland from the rank of Commander to the rank of Captain in the United States Navy.

DR. KIRKLIN APPOINTED X-RAY CONSULTANT

Dr. B. R. Kirklin of the Mayo Clinic, Rochester, Minnesota, has been appointed as X-Ray Consultant in the Office of the Surgeon General of the Army, with the rank of Colonel.

Vol. 49, No. 6

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 103 Rutledge Ave.
Charleston, S. C.

AN INEXPENSIVE CASSETTE CHANGER FOR ANGIOCARDIOGRAPHY

By EDWARD B. D. NEUHAUSER, M.D., *and* CHARLES G. JENNINGS, M.D.
From the Department of Roentgenology of The Infants' Hospital and The Children's Hospital
BOSTON, MASSACHUSETTS

ANGIOCARDIOGRAPHY or the visualization of the great vessels and the cardiac chambers by roentgen examination after the injection of a radiopaque substance into the venous system is now a well recognized accessory method of study of abnormalities of the cardiovascular system. There is only one part of the examination that presents any considerable difficulty, and that is the rapid exposure of the six to eight films in as many seconds, without which the examination is apt to prove of little value. There are several adequate methods available for procuring such a series of roentgenograms, but for those roentgenologists who only occasionally perform this type of examination, the equipment is either too expensive or too bulky when so infrequently used.

To meet this objection, we have designed a small, inexpensive and effective semi-automatic cassette changer. The apparatus was made in a few hours by the Hospital carpenter at a total cost of two dollars and fifty cents. Basically, this cassette changer is an open-topped box, sufficiently large to accommodate eight 11 by 14 in. cassettes without any unnecessary free play at either side or end. The bottom cassette rests on a platform which is supported by four ordinary bed springs which should be strong strong enough to raise a weight of 60 pounds. When the cassette changer is loaded the platform is depressed with resulting compression of the springs. With the pressure being exerted by the springs, the platform with the superimposed cassettes tends to rise until the top cassette is stopped by a small flange at either end of the container box. To procure an even rise of the platform each end of the platform has two small projections that fit into grooves in the end pieces of the box.

All of our angiocardiography has been done with children and we have found that it is more satisfactory to have the patient

Fig. 1. Shows the cassette changer in place and strapped to the table beneath the canvas frame which supports the patient clear of the box.

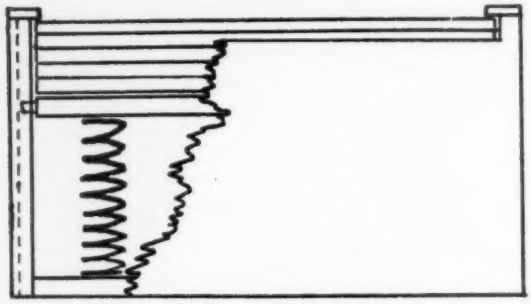

FIG. 2. A vertical elevation shows the platform and one supporting spring. Five cassettes are shown in place.

anesthetized during the administration of the radiopaque substance and the exposure of the films. The child is placed on a low canvas frame, supported by four legs which rest on the table top, as shown in Figure 1. The cassette changer is placed beneath the canvas frame and fastened to the table top with suitable straps. The height of the frame should just clear the top of the cassette holder. The patient may be placed in any desired position, but we have found that in general the left anterior oblique is most satisfactory. Because the roentgen rays will penetrate the top cassette, it is necessary to back each cassette with lead foil, so that the rays reach only one film at a time. We have found that 1/64 inch foil is sufficient protection for the following factors: 76 kv., 400 ma., and 1/60 second at 40 inches, but if a heavier exposure is contemplated, it might be wise to use double the thickness. The foil is cut to size and a piece fastened on the back of each cassette with adhesive tape.

In angiocardiography we have employed 20 cc. of 75 per cent diodrast and a needle that is large enough to allow the injection to be completed in about two seconds. As the plunger meets the bottom of the syringe, a signal is given and the first exposure is made. The top cassette is then pushed out of the holder by an assistant and retrieved on the opposite side of the table by a second assistant who places the cassette on a convenient chair or stool. The second cassette rises into position and the next exposure is made and the process repeated until all films contained in the box have been exposed. When a large cone is used with the tube we have not found sufficient scattered radiation to fog any of the exposed film. It is important that each assistant wear a protecting apron as some exposure to scattered radiation is unavoidable.

In a series of twelve angiocardiograms we have found the method very convenient and satisfactory, and with a little practice it is possible to make one exposure every second.

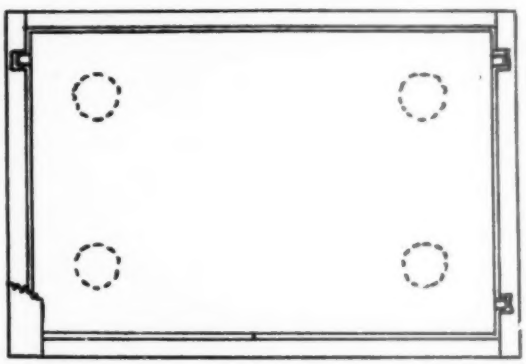

FIG. 3. Horizontal section shows the position of the four springs beneath the platform and also the flanges and grooves at either end of the platform.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

GYNECOLOGY AND OBSTETRICS

HARPER, R. A. K. Congenital duodenal obstruction. *Brit. J. Radiol.*, Nov., 1941, *14*, 360–363.

Congenital obstruction of the duodenum is very rare and is generally diagnosed in early infancy. A case is described which is unusual from the fact that the obstruction did not cause serious enough results to necessitate examination until the patient was twenty years old. He had always had a feeling of distention of the abdomen after eating and had vomited almost daily all his life. When he came for examination his abdomen was distended. Roentgen examination showed fluid levels in the upper abdomen. There was marked distention of both stomach and duodenum and fluid levels in the duodenum. The obstruction was at the duodenojejunal flexure and very little barium left the duodenum in the first five hours. The examination also showed non-rotation of the cecum.

Gastrojejunostomy was performed and the patient made an uneventful recovery. The obstruction was probably due to fixation of the duodenojejunal flexure during the development of the intestine.

Obstruction of the duodenum is frequently associated with other congenital anomalies and in this case the patient showed cleft palate and non-rotation of the cecum.—*Audrey G. Morgan.*

OGILVIE, ROBERTSON F. Duodenal diverticula and their complications with particular reference to acute pancreatic necrosis. *Brit. J. Surg.*, Jan., 1941, *28*, 362–379.

Duodenal diverticula are found quite frequently on postmortem examination and were formerly considered anatomical curiosities. Case in 1916 first demonstrated one during life by roentgen examination and since then they have been excised by a number of surgeons. As late as 1939 Edwards in his book on "Diverticula and Diverticulitis of the Intestine" says that the association of pancreatitis with diverticula of the second part of the duodenun is vague and usually accidental.

In this article 4 cases of perivaterine diverticulum are described which refute this idea. In the first case there was obstruction and dilatation of the pancreatic duct and common and and cystic bile ducts as well as the gallbladder. This had resulted in atrophy of the pancreas. The patient died of obstructive jaundice. In all of the other 3 cases the diverticulum was associated with acute necrosis of the pancreas. There is evidence that in the majority of cases necrosis of the pancreas is caused by obstruction of the ducts. This does not always occur, however, as shown by Case 1, and it is probable that the occurrence of necrosis is dependent on the degree of secretory activity of the glands. In experimental work ligation of the pancreatic duct produced necrosis only when performed during digestion.

Other complications of duodenal diverticula are diverticulitis, which may result in inflammation of surrounding tissues. Diverticulitis of duodenal diverticula is rare, however, as they drain freely into the intestine. The diverticula may contain enteroliths or gallstones. Only 1 case of carcinoma of a duodenal diverticulum has been reported in the literature.—*Audrey G. Morgan.*

FELDMAN, MAURICE. A roentgenologic consideration of the normal mucosa of the duodenum. *Radiology*. Sept., 1941, *37*, 284–288.

A careful study of the mucosa of the duodenum is important as it helps to define the roentgen appearance of beginning disease of the duodenum. Heretofore early changes in the second portion of the duodenum have been overlooked or misinterpreted frequently.

The author presents a detailed roentgen study of the descending portion of the duodenum which is particularly interesting because of its relation to the head of the pancreas and the biliary and pancreatic ducts. The findings are described in detail and illustrated with roentgenograms. The union of the two ducts forming the papilla of Vater can be seen. There is a circular hood-like fold surrounding the papilla at the lower end of the plica longitudinalis. Some of the transverse, or Kerkring's folds pass over

the longitudinal fold while others end at it. The normal minor papilla cannot be seen in the roentgenogram. The relation of the head of the pancreas to the common and pancreatic ducts and the major papilla is shown.—*Audrey G. Morgan.*

Portis, Sidney A. The clinical significance of the roentgenologic findings of the small intestine. *Radiology*, Sept., 1941, *37*, 289–294.

The author mentions some significant findings in the small intestine such as the association of rapid motility shown by roentgen examination with achlorhydria and segmentation of the small intestine with corresponding dilatation of the individual coils or groups of coils in vitamin B deficiency. The mucosal pattern may be distorted and emptying time delayed. Vitamin A disturbance of the small intestine may be confused with the clinical picture of idiopathic steatorrhea. In idiopathic steatorrhea the valvulae conniventes may be obliterated to such an extent that the bowel may look like a tube through which wax has been poured and allowed to harden. There may also be dilatation of the lumen and spasm with sausage formation or segmentation. He describes the roentgen findings in a case of Hodgkin's disease of the upper jejunum.

Though roentgen examination of the small intestine is of great importance there seems at present to be no definite standardization of roentgen technique for such examination. Attempts are being made to standardize the technique by experimenting with small and large meals and adding various non-irritating drugs which delay motility. Because of the complexities of metabolism and digestion in the small intestine it will probably never be possible to demonstrate definite patterns in the mucosa corresponding to different diseases but definite conclusions in regard to pathognomonic roentgen findings will only be arrived at by correlating the clinical symptoms with repeated roentgen examinations.—*Audrey G. Morgan.*

Rigler, Leo G. Spontaneous pneumoperitoneum: A roentgenologic sign found in the supine position. *Radiology*, Nov., 1941, *37*, 604-607.

A diagnosis of rupture of the stomach, small or large intestine can be confirmed by roentgen examination. It has heretofore been necessary to make the examination with the patient standing so that the gas might collect beneath the diaphragm. But now it has been found that there is a sign that can be seen in the ordinary preliminary roentgenogram of the abdomen with the patient lying down. In such roentgenograms if there is air in the peritoneal cavity the outer as well as the inner wall of the bowel can be seen. Gas passes between the adjacent loops of intestine so that the outer wall of each loop can be seen. This sign occurs only in pneumoperitoneum.

Therefore frequent roentgenograms should be taken in cases of obstruction of the intestine under observation. With such films it may be possible to detect perforation before there are any clinical signs.—*Audrey G. Morgan.*

Altman, W. S. Cholangiography, fractional method. *Radiology*, Sept., 1941, *37*, 261–268.

Cholangiography is used almost as a matter of routine in cases of biliary surgery at Beth Israel Hospital, Boston. In the fractional method the first films are taken in the operating room, using 80-90 kv., 30 in. distance and 60 ma-sec. Most patients are given spinal anesthesia so that respiration can be suspended voluntarily during operation. The cystic duct is exposed and a small ureteral catheter introduced into it. Bile is aspirated through the catheter and examined. Then 3 to 5 cc. diodrast is injected into the duct. A single film is then taken, a larger amount of diodrast (8–10 c.c.) injected and a second film taken. These films are examined and interpreted during the operation. If there are no indications for exploration of the common duct no further films are necessary. If the common duct is to be examined another check-up film is taken before the abdomen is closed.

Postoperative cholangiography is done in the roentgen department. Bile is aspirated and about 4 cc. diodrast injected. If it is advisable to flush the tube with saline previous to the installation of the contrast medium larger amounts are injected (6 to 10 cc.) and stereoscopic films are taken. Then the patient inhales amyl nitrite, 4 to 5 cc. more injected and a fourth film taken. The amyl nitrite relaxes Oddi's sphincter, giving better visualization of the intramural part of the ampulla.

The fractional method has proved of value in diagnosis where there was difficulty in interpreting a single film an account of motion caused by breathing, spill or leakage around the catheter or T-tube, air bubbles, kinks in the cystic

or common ducts, overlapping bone shadows, superimposition of the cystic duct on the common duct, superimposed instruments, catheters or T-tubes, anomalies or artifacts.

The author discusses 109 cases in which he used the method. There was only one death, a mortality of less tham 1 per cent. This patient was a man of seventy with a partially gangrenous gallbladder who died three days after opertion of acute kidney failure. The method therefore certainly involves no added risk.—*Audrey G. Morgan.*

DIPPEL, A. LOUIS, and DELFS, E. The accuracy of roentgen estimates of pelvic and fetal diameters. *Surg., Gynec. & Obst.*, May, 1941, *72*, 915–922.

Modern roentgen pelvimetry and fetometry have been developed greatly during the past few years and are now in use by many hospitals and teaching institutions. Many obstetricians do not use them, however, because they are not convinced of their precision.

The authors therefore try to evaluate the accuracy of several roentgen methods commonly used for these measurements. The simplest method is that of Thoms' inlet view but it is accurate only when the external bony landmarks are properly selected. There is a considerable degree of variation in the pelvis in different individuals and sometimes the plane of the pelvic inlet cannot be accurately located, even from these bony landmarks.

It has been claimed that roentgenograms taken from a distance of 6 feet are not distorted but the authors show by means of similar triangles that teleroentgenograms are not accurate; fetal and pelvic measurements are overestimated from them by about 10 per cent.

In stereoscopic films markers must be used and it is necessary to use the exact tube-film and tube-shift distances called for by the technique in use. Hodges' laboratory has a precise roentgen machine in which the tube-film and tube-shift distances have been calibrated and they cannot be altered. But most laboratories do not have such machines and the authors give two mathematical methods for making precise estimates from stereoscopic films taken by a non-precision roentgen machine. They have found the Hodges graphic, the precision and the stereoroentgenographic methods about equally accurate in estimating maternal pelvic and fetal measurements. The Thoms and Hodges lateral methods of measuring the anteroposterior diameters of the pelvis are quite accurate but with the former the lead ruler must be placed accurately in the median plane of the pelvis for correct results. Both of these methods are apt to fail of absolute accuracy in asymmetrical pelves. A table is given showing the roentgen estimate of the obstetrical conjugate in 6 cases by the various methods as compared with the direct measurement of museum specimens of pelves or of patients on laparotomy.—*Audrey G. Morgan.*

FROSTBERG, NILS. Fall von Röntgendiagnostizierter Tympania uteri. (Case of tympany of the uterus diagnosed by roentgen examination.) *Acta radiol.*, 1941, *22*, 387–392.

A case is described in a primipara thirty-four years of age admitted to the hospital on March 9, 1940. In 1936 she had been treated for myoma of the uterus and cyst of the left ovary. On this admission she had rapid pulse, temperature 37.6° C., distended abdomen and great difficulty in urination. The head of a fetus, evidently dead for some time, as it showed maceration of the third degree, lay in front of the vulva.

Roentgen examination was made, chiefly to determine whether the patient had peritonitis. It showed the uterus greatly distended with gas; the fetus, placenta and umbilical cord could be seen plainly in it. No peritonitis. As soon as the fetus was delivered the umbilical cord ruptured and a large amount of vile-smelling gas was discharged. The cord was only 23 cm. long. With the discharge of the gas the abdomen collapsed. In spite of blood transfusion the patient died that evening. The labor complication was probably caused by the short cord and the high position of the placenta. Autopsy showed necrotic, gas-filled foci in the spleen and kidneys. Microscopic examination showed short chains of bacilli, probably Welch bacilli. In delayed labor with infected amniotic fluid gas in the uterine cavity can be demonstrated by roentgen examination.—*Audrey G. Morgan.*

TORPIN, RICHARD, and HOLMES, L. P. Roentgen diagnosis of intra-uterine hydrocephalus. *Radiology*. Sept., 1941, *37*, 351-352.

A case of roentgen diagnosis of intrauterine hydrocephalus is described. The lateral soft tissue method was used supplemented by a study of the obstructed labor by the grid method in which the roentgen pelvimeter devised at the University Hospital of Georgia was used. This

gives an 8×10 inch film showing the fetal head framed in the inlet.

The lateral film showed the skeleton of a fairly large fetus without spina bifida but with a very large head. The height of the fundus was 1 cm. greater than the average indicating a large head. The head was hard and measured through the abdominal wall 14 cm. in transverse diameter Though it was not certain which diameter this was it indicated a large head. After Twenty-four hours of fairly hard labor and twenty hours after the rupture of the membranes the fetus was delivered by low cesarean section. The child weighed 9 pounds, 8 ounces but had the body of about an 8 pound normal infant. The head was relatively too large for the body and showed the bulging forehead and deep-set eyes of typical hydrocephalus. Tracings from roentgenograms are given of the skull of a normal fetus, those of the hydrocephalic child and those of a giant fetus recently seen, and a table is given showing the comparative measurements of the three.—*Audrey G. Morgan.*

GENITOURINARY SYSTEM

Cahill, George F. Tumors of the adrenal and the use of air insufflation in their diagnosis. *Radiology*, Nov., 1941, *37*, 533–544.

In 1921 Cahill first described a method of diagnosis in adrenal conditions which consisted of introducing air into the perirenal fascial planes. This outlined the kidneys and adrenals more clearly than ordinary roentgenography. The author has used it in several hundred cases since 1930 without any bad results and with distinct advantage in diagnosing tumors of the adrenal. He gives a classification of tumors of the adrenal and discusses the use of the method in the different classes, illustrating them with roentgenograms.

Dr. Joelson said in the discussion that while Dr. Cahill had been so successful with the use of this method in such a large series of cases the method is not entirely free of danger. In a smaller series of cases at Lakeside Hospital they had had no fatalities but in several cases there were symptoms due no doubt to air embolism. In a fair percentage of cases tumors of the adrenal can be demonstrated on ordinary films. They have recently had 4 cases in which the demonstration was made in this way.

Dr. Cahill replied that in the injection of air into the perirenal fascial planes there is some danger of air embolism but that if care is taken the danger is slight and more than outweighed by the value of the films. There is more danger in large tumors with tortuous, thin-walled vessels and the method is not recommended in these cases. It is most useful in the diagnosis of small tumors that cannot be demonstrated in any other way. As there is danger in surgical exploration in these cases the patients should be given the advantage of this method to determine the side on which the tumor is located. The amount of air used depends on the size of the patient and the type of tumor. Patients with edema and fat deposits require more air for the demonstration of the tumor than thin ones. —*Audrey G. Morgan.*

Kirwin, Thomas J. Papillary carcinoma of the renal pelvis; diagnosis and treatment. *Surg., Gynec. & Obst.*, Dec., 1941, *73*, 759–765.

Papillary carcinoma of the renal pelvis comprises approximately 5 per cent of all renal tumors. Hematuria is the only early sign and should always be thoroughly investigated by every possible clinical and roentgenological procedure until a diagnosis is established. The retrograde or excretory pyelograms may show filling defects, deformity of calices and evidence of obstruction. Aspiration of material through the ureteral catheter will sometimes result in histopathological evidence of malignancy. Treatment is surgical and should include nephrectomy and ureterectomy because of the known tendency for transplants to occur in the ureter and bladder.

A case report is included.—*G. W. Chamberlin.*

Stirling, W. Calhoun, and Ash, J. E. Papillary adenocarcinoma of the kidney; hypernephroid tumors. *Surg., Gynec. & Obst.*, Sept., 1941, *73*, 305–311.

Exclusive of the tumors of the renal pelvis, Wilms' tumor, and tumors of the renal blastema, the tumors of the kidney are adenoma, adenocarcinoma, papillary adenocarcinoma with clear and granular cells.

The origin of papillary adenocarcinoma is not yet certain. True hypernephroma may occur, but many facts point to the renal origin of these tumors. The most important point in the argument against the adrenal origin of these tumors is the lack of the secretion of cortin by the cells of these tumors.

Papillary adenocarcinoma is the most common tumor of the kidney in adults. It may develop slowly and become massive before it is

detected. Different portions show different gross appearances. Some areas may be yellow, others red. Calcification or cystic degeneration may occur. The tumor tends to grow into the renal pelvis and vein. The lungs and bones are the most common sites of metastasis. Early diagnosis is necessary. Symptoms are frequently absent or scarce. Hematuria, in large or small amount, should always be investigated. A large mass in the loin is usually a late manifestation.

The study of a suspected renal tumor should include a primary intravenous urogram to determine the comparative size, function, and appearance of the calices and pelves. Cystoscopic examination with bilateral pyelograms should follow. Too much reliance should not be placed on a single negative pyelogram because the lesion may be obscured by the dye. Intravenous urography with multiple films is sometimes more satisfactory than retrograde studies.

The authors recommend preoperative radiation therapy for those patients who give a short history and have a fixed mass. Metastases should be searched for before operation. In large tumors, the transperitoneal approach offers better exposure for early clamping of the renal pedicle.—*G. W. Chamberlin.*

HUGGINS, CHARLES, STEVENS, R. E., JR., and HODGES, CLARENCE V. Studies on prostatic cancer. II. The effects of castration on advanced carcinoma of the prostate gland. *Arch. Surg.*, Aug., 1941, *43*, 209–223.

Twenty-one patients with demonstrable metastases or local extension of the prostatic cancer outside the capsule of the prostate were treated by orchidectomy. Fifteen had roentgenologically demonstrable metastases in the pelvis or spine. Most had osteolytic and osteoblastic metastases and 1 had a pathological fracture of the pelvis.

The acid phosphatase, in 8 cases in which malignant tissue was available, was comparable to that found in the normal adult prostate and much greater than in the newborn infant. This suggests that the cells of the prostatic malignancy are of adult epithelium.

In patients with carcinoma of the prostate who had marked elevation of the serum acid phosphatase, castration caused a reduction toward normal which was maintained for many months.

Eighteen of the 21 patients showed clinical improvement following orchidectomy. There was relief of pain, gain in weight, and an upward trend of the erythrocyte count.

In all cases, except 1, the prostate gland decreased to a small size, and in many cases, it became soft and so small that it could scarcely be palpated.

In all cases in which metastases to bone were present, increased osteosclerosis occurred within three to six months. The 1 case of pathological fracture became united.

Untoward results of castration were temporary swelling of the ankles, development of hot flashes, and the abolition of sexual capacity. The hot flashes could be eliminated by using estrogenic substance.—*G. W. Chamberlin.*

KAUFMANN, WILLIAM, and WRIGHT, ARTHUR W. Lymphosarcoma of the prostate gland. *Arch. Surg.*, Dec., 1941, *43*, 1061–1075.

This article consists of a review of the literature and a detailed case report of primary lymphosarcoma of the prostate. Justification for this presentation lies in the controversial opinions regarding the possibility of such a primary lesion. The case reported tends to support the author's contention that primary lymphosarcoma of the prostate does occur. It is a rapidly growing neoplasm which infiltrates the surrounding tissues. It may arise from preexisting lymphoid tissue or from tissue formed as a result of previous chronic inflammation. The tumor is resistant to radiation therapy. Extreme care must be exercised to differentiate this tumor histopathologically and clinically from anaplastic carcinoma of the prostate.—*G. W. Chamberlin.*

PRINCE, C. L., and VEST, S. A. Leiomyosarcoma of the prostate; report of a case and critical review. *J. Urol.*, Dec., 1941, *46*, 1129–1143.

Leiomyosarcomas differ from leiomyomas histopathologically in the following findings: increased cellular pleomorphism, hyperchromatic nuclei, mitotic figures, decreased acidophilic character of the cytoplasm and invasion of contiguous structures. Their occurrence in the prostate is unusual.

The authors report a case in a man, aged fifty-two, who was admitted with complaints of dysuria, frequency and hematuria of two years' duration. The prostate was hard, enlarged and asymmetrical. A biopsy obtained with the McCarthy resectoscope showed leiomyosarcoma. No evidence of metastasis could

be found. Due to the radioresistance of muscle tumors a radical perineal prostatectomy was performed. Examination one year after operation showed no local recurrence and no evidence of any metastatic lesion.

The authors found a great deal of confusion in the literature on prostatic sarcomas. Some authors denied the existence of muscle cell tumors of the prostate. The authors of this paper found 15 cases in the literature of leiomyosarcoma of the prostate and they have summarized their main features in tabular form.

The etiology of this tumor is obscure; the symptoms are those of prostatic obstruction, and the diagnosis is usually made only on biopsy. Metastases were present in 40 per cent of cases. Local extension occurred in 85 per cent of the cases. The prognosis is poor. The only hope for cure is radical perineal prostatectomy. The tumors are too radioresistant for cure by irradiation.

From their studies the authors conclude that this type of sarcoma is the least malignant prostatic sarcoma in the adult. They feel that it is important to try to make a differential diagnosis in prostatic sarcomas for this reason.—*R. M. Harvey.*

Barringer, Benjamin S., and Earl, David. Teratoma testis. *Surg., Gynec. & Obst.*, March, 1941, *72*, 591–600.

This article is a survey of general information obtained from a group of 37 patients with teratoma testis who came to autopsy.

The majority of cases in this series had either surgical or radiation treatment. The average age of the patients studied was 31.5 years. Nineteen cases were radiosensitive embryonal carcinoma; 10 were embryonal adenocarcinoma, somewhat less sensitive; 3 were radioresistant chorioepithelioma, and 1, adult teratoma. The right testicle was involved 19 times, the left 18 times. Abdominal cryptorchidism with teratoma occurred 4 times. The Aschheim-Zondek reaction as carried out on these cases was positive in 85.7 per cent of the cases, but there is some question regarding the accuracy of this figure. Gynecomastia occurred in 2 cases.

Metastasis occurred both by lymphatic and hematogenous means. They are most frequent in the upper abdomen and in the external iliac on the same side as the primary tumor. If there is a supraclavicular node other metastatic nodules may be present all along the thoracic duct. Inguinal nodes are not involved unless the tumor has perforated the tunica vaginalis or the capsule of the testicle. In 10 cases there was node involvement which extended from the pelvis to the left supraclavicular area. The mediastinal nodes were involved in 48 per cent; intracranial involvement was present in 16 per cent, and the lungs were involved in 78 per cent of the cases. Metastases to bones, genitourinary, and gastrointestinal tract, were less common. In nearly all the cases, there was bilateral involvement in the abdomen either of lymphatic glands or intra-abdominal organs.—*G. W. Chamberlin.*

Finestone, Edward O. Urinary extravasation (periurethral phlegmon). *Surg., Gynec., & Obst.*, Aug., 1941, *73*, 218–227.

The author states that seven factors play parts in determining the characteristics of extravasation: (1) anatomical distribution of fascial planes; (2) nature and location of the urethral lesion; (3) hydrostatic pressure of the extravesic fluid; (4) vascular obstruction induced by pressure of perineal abscess or extravasated fluid; (5) occurrence of vascular thrombosis or thrombophlebitis; (6) elasticity, tonicity, and contractility of the tissues and muscles; (7) nature of the invading organism.

In this article, there is a discussion of the anatomy of the perineum, followed by a series of experiments upon cadavers. Specimens were injected with radiopaque and colored solutions through a needle in the perineal triangle. Measurements were made of the amount injected and the pressure applied at intervals as control films were exposed.

These experiments failed to reveal any case wherein the tunica vaginalis testes was involved, so that operations on the deeper structures of the scrotum are considered unnecessary.

The author indicates the importance of diversion of the urinary stream in all cases of periurethral obstruction whether or not they have clinical evidence of obstruction.—*G. W. Chamberlin.*

Graves, R. C., and Guiss, L. W. Tumors of the urethra. *J. Urol.*, Nov., 1941, *46*, 925–947.

Primary urethral tumors are rare. The authors treat benign papillomata with radium implantation following biopsy and coagulation. In male patients they administer 200 mc-hr. with a small brass or silver capsule introduced

into the urethra. Carcinoma of the male urethra is very rare. The authors encountered 1 case in 19,000 admissions to a hospital for the treatment of neoplasms. The best treatment is amputation of the penis and radical dissection of the glands of the groin.

The commonest benign tumor of the female urethra is the caruncle. They tend to recur if incompletely removed. Electrodesiccation is the ideal method of treatment. Extensive scars must be avoided or strictures will result. Ten cases of carcinoma of the female urethra were encountered in the same series of 19,000 admissions in which 1 carcinoma of the male urethra was seen. The symptoms consist of bleeding, pain on urination, or urethral obstruction. Irradiation is gradually replacing radical surgery in the treatment of carcinoma of the female urethra.

The authors favor irradiation in the early and moderately advanced cases of epidermoid carcinoma. In advanced cases and especially in adenocarcinoma, radical surgical extirpation may be necessary. The authors use radium needles placed interstitially around and parallel to the lumen of the urethra, 0.5 cm. from its mucosa. Four needles are placed above, below and to each side of the urethra and a fifth needle in the midline just beneath the symphysis. Additional needles are introduced laterally and inferiorly for lymphatic blockage. The lymphatics drain to the inguinal glands.

One case report of epidermoid carcinoma in the male and one of benign papilloma in the male are presented together with case reports of 8 females with carcinoma of the urethra. In the presence of palpable inguinal glands the authors advise radical bilateral surgical dissection. They do not advise prophylactic dissection of the glands in the absence of palpable enlargement.—*R. M. Harvey.*

NERVOUS SYSTEM

HAMBY, WALLACE B. Misplaced spinal lipiodol: an analysis of 104 lipiodol spinograms. *Radiology*, Sept., 1941, *37*, 343–346.

A striking case of displacement of lipiodol led the author to make an analysis of 104 spinograms from the hospitals of Buffalo. He found displacement of the lipiodol into the subdural or epidural space in 8 of them, or 7.7 per cent. The oil had been introduced by cisternal puncture in 13 of these cases and by lumbar puncture in 91. It was misplaced in 3 of the cisternal cases, or 23 per cent, and in 5 of the lumbar cases, or 5.4 per cent.

If lipiodol is displaced into the epidural space it appears in the roentgenogram as a relatively fixed, irregular, opaque mass which a few days later tends to be widely diffused through the canal, either in the form of minute droplets or in that of a mass extending outward along the nerve roots. Subdural lipiodol flows rather freely but tends to outline defects that are not constant in serial studies. It remains more or less in a mass instead of becoming widely diffused.

The factor that was constant in these cases of displaced lipiodol was that spinal fluid pressure had been reduced previously either by lumbar puncture or, more commonly, by air spinography. Therefore it is advisable if lipiodol is to be injected after air spinography to wait at least ten days before injecting the oil.—*Audrey G. Morgan.*

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[FOUNDED IN 1906 AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

The AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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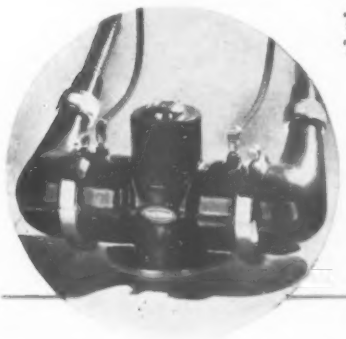

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